(B) Base Isolation System

For the recommended plan for the base isolation system refer to Chapter 10-3-2 (1) (B).

Lead rubber bearing isolation devices of ϕ 400 and ϕ 550 are recommended and those are shown in Table 10-25.

Table 10-25 The Lead Rubber Bearing Isolators

Diameter of Device		Sectional area (mm^2)	Recommended Max. Axial Load (kN)	Recommended Isolator
Outside (mm)	Inside (mm)			
400	150	1,080	1,080	¦
450	150	1,414	1,410	
500	150	1,787	1,780	
550	200	2,061	2,060	¦
600	200	2,513	2,510	
700	200	3,534	3,530	

Note: Recommended maximum axial load on the device is assumed based on 1.0 kN/mm^2 of compression on the rubber.

The calculated load supported by the isolators and the number of isolators required are shown in Table 10-26.

Table 10-26 Calculated Supporting Load by Isolator and Designed Isolator

Place	Weight of Super-Structure (kN)	Weight of Underground Wall (kN)	Weight of 1st Fl. Slab plus Live Load (kN)	Weight of New RC Beam (kN)	Total Load (kN)	Isolator (Dia., Nos.)
SENATE Building	177,455	32,000	14,000	20,000	243,455	Φ 550: 127 Nos., Φ 400: 47 Nos.

Note: Weight of 1st floor slab plus live load (0.50 kN/m^2) for seismic design is assumed to be 11.0 kN/m^2.
Weight of new RC beams which support the bearing walls is assumed to be 10.0 kN/m^2.

10-3-3 RC Buildings

As indicated in Chapter 9-1-2, more than half of all existing buildings in the study area of Wilaya Algiers are reinforced concrete moment frame buildings, and the moment frame system is the main structural system of existing reinforced concrete buildings. Seismic evaluation and retrofit is recommended for these existing reinforced concrete moment frame buildings to mitigate damages by earthquakes.

(1) Methodology of Seismic Retrofit Existing Reinforced Concrete Buildings

Seismic retrofit design of existing reinforced concrete buildings followed:

Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001 and Technical Manual for Seismic Evaluation and Seismic Retrofit of Existing Reinforced

Concrete Buildings, 2001 (English version, 1st edition), The Japan Building Disaster Prevention Association, Tokyo, Japan --- Reference 1

A plan and basic design of seismic retrofit for existing reinforced concrete buildings was executed for three buildings, an apartment house, a school building and a hospital. The second level seismic screening procedure was applied, which was the same level as the seismic evaluation before the retrofit. The results of the seismic evaluation for these three buildings before retrofit have been shown in Chapter 9-1-2.

(2) Target of Retrofit

Seismic Demand Index, Iso, and $C_T S_D$ as retrofit targets were evaluated based on the earthquake damage surveys and the estimated seismic intensity that could be produced by scenario earthquakes as shown in the Appendix 1. These were calibrated with current seismic design code in Algiers to meet the required seismic capacity as follows;

1) Strength and Ductility of Current Seismic Design Code, RPA99 ver. 2003

Design Seismic Load is calculated by following formula;

V = (ADQ/R)*W

A: Zone acceleration coefficient (Zone III, Algiers),

0.25 for Group 2 (Moderate Importance)

0.40 for Group 1A (Vital Importance) 0.4/0.25 = 1.6

D: Dynamic amplification factor, max. 2.5 where 0 < T < 0.5 sec. (S3)

$D = 2.5 \times \sqrt{}(7/(2+7) = 2.2$, for typical RC frame structure

R: Structural behavior factor, for typical RC frame structure, R = 3.5 was used,

Q: Quality factor, Q = 1.15 for typical case

Design base shear coefficient for a typical RC frame structure is calculated as follows;

D.B.S.C = V/W = 0.25 x 2.2 x 1.15/3.5 = 0.181, or = 0.157 in case Q = 1.0.

Strength Index, C, is estimated at 0.20 and more.

2) Seismic Demand Index, Iso,

Seismic Demand Index, Iso, is shown by the following formula;

Iso = Es Z G U

Es: Basic Seismic Index of Structure, **0.6** for second and third level screening in the Japanese Standard

Z: Zone Index, Z = 1.0 typical (1.0, 0.9, 0.8, 0.7)

G: Ground Index, G = 1.0 typical (1.0, 1.25)

U: Usage Index, U = 1.0 typical (1.0, 1.25, 1.50)

The seismic index of structure, Is, is expressed by;

$Is = EoS_DT = CFS_DT = CF \times 0.9$ (where $S_DT = 0.9$)

If the supposed minimum Strength Index by RPA99ver.2003 is applied,

C = 0.20 (Strength Index), and supposed F = R = 3.5,

$Is = 0.20 \times 3.5 \times 0.9 = 0.63 > 0.60$

or $0.157 \times 3.5 \times 1.0 = 0.55$ (where Q = 1.0 and $S_DT = 1.0$)

From the above estimation and the data shown in Appendix 1, the following formula is recommended for the Seismic Demand Index of Structure, Iso, for RC buildings in Algiers;

Iso = (0.50 ~ 0.60) U (where Z = G = 1.0)

A range of 0.50 to 0.60 is recommended. The minimum demand index is0.50, however, 0.60 is a desirable demand index, and this range will be reduced after reviews of future retrofit case studies.

If the Usage Index is applied, Iso is as follows,

Iso = 0.625 to 0.75 (U = 1.25)

Iso= 0.75 to 0.90 (U = 1.50)

3) The product of the Cumulative Strength Index and the Irregularity Index, C_TS_D

The product of the Cumulative Strength Index and the Irregularity Index, C_TS_D is another condition to estimate the 'Safety' of a building and is applied to buildings with generally ductility-dominant structures. A value of 0.30 is used in the Japanese Standard as follows;

$C_TS_D \geq 0.30 ZGU = 0.30 U$ (where Z = G = 1.0)

C_T : Cumulative Strength Index at the ultimate deformation of the structure

S_D : Irregularity Index

Z : Zone Index, G: Ground Index

A range of 0.20 to 0.30 is recommended for RC buildings in Algiers,

$C_TS_D \geq$ (0.20 ~ 0.30) U (where Z = G = 1.0)

The minimum demand index is 0.20; however, 0.30 is a desirable demand index, and this range will be reduced after future reviews of the case studies of the building strength designed in compliance with RPA99 ver. 2003.

If Z and G are both 1.0, and Usage Index U is applied, C_TS_D is expressed as follows;

$C_TS_D \geq 0.25$ to 0.375 where U = 1.25

$C_TS_D \geq 0.30$ to 0.45 where U = 1.50

(3) A Plan and Basic Design of Seismic Retrofit

A plan and basic design of retrofit for the following three buildings is shown in this section;

- A Five Storey Apartment House, designed based on RPA 88
- A Two Storey Elementary School, designed based on RPA 88
- Pierre and Marie Curie Center Chemo-Therapy Building, Mustapha Hospital, designed based on RPA83. This hospital has been nominated as a strategically important building.

The results of the seismic evaluation of the above buildings before retrofit are shown in Chapter 9-1-2 and these buildings were evaluated as being 'Not Safe'.

1) A Five Storey Apartment House

(A) General

This building is a typical apartment house of reinforced concrete moment frame, and was designed based on RPA88. Materials used, loading condition and the results of the seismic evaluation before retrofit have been shown in Chapter 9-1-2 (1). It is noted that the ductility index of some columns was inadequate because of the high axial force ratio at the 1st storey, and the collapse of these columns would cause the destruction of the building.

(B) A Plan and Basic Design for Retrofit

An idea of retrofit using column jacketing was not used considering that there would be a great impact to existing finishing works near columns and that the continuous strengthening of columns from the 1st storey to 4th storey would be difficult. Another method that provides RC walls was applied instead, which is a typical retrofit method to increase strength. RC walls were provided for the 1st storey to the 4th storey in the X and Y directions as shown in Figure 10-21 and Figure 10-22. These were flexural walls with a ductility index of 2.0. To mitigate the works inside of the house, walls in the Y direction were provided at grid 1 and grid 7. There were no suitable positions for RC walls at the perimeter in the X direction because of required openings. RC walls were provided at grid C. In this case existing doors had to be relocated as shown.

Materials adopted for the retrofit are as follows;

- Main re-bar σy = 400 N/mm^2 (400 x 1.05=420, 5% of allowance was estimated for retrofit)
- Hoop σy = 230 N/mm^2 (230 x 1.05=240, 5% of allowance was estimated for retrofit)
- Concrete strength = 25 N/mm^2 (original design strength)

(C) Target of Retrofit

Usage Index = 1.0 was applied. Seismic Demand Index Iso = 0.50, $C_T S_D$ = 0.20 was used. These are minimum requirements for retrofit.

(D) Result of Seismic Retrofit

The seismic index of the structure, Is, and CTSD after retrofit are shown in Table 10-27 and Figure 10-19. The relationship of the ductility index and the strength index at the 1st storey is shown in Figure 10-20. Typical details for retrofit of reinforced concrete walls are shown in Figure 10-23.

A summary of the results is as follows;

- Is of the 1st, 2nd, 3rd and 4th storey were increased to more than 0.50.
- C_TS_D of the 1st, 2nd 3rd and 4th storey was increased to more than 0.20.
- Is and C_TS_D of 5th storey decreased because of the lower S_D, but values were still more than the required values.

Table 10-27 Seismic index of Structure, Is, and C_TS_D after Retrofit

Storey	After Retrofit				Before Retrofit	
	X direction		Y direction		X, Y direction	
	Is	C_TS_D	Is	C_TS_D	Is	C_TS_D
5	0.82	0.26	0.82	0.26	1.02	0.32
4	0.78	0.40	0.71	0.36	0.60	0.19
3	0.58	0.34	0.59	0.30	0.47	0.16
2	0.59	0.30	0.54	0.27	0.53	0.18
1	0.51	0.26	0.52	0.26	0.40	0.18

SD; 0.76 (5th storey), 0.95 (1st to 4th storey after retrofit), 0.95 (all stories before retrofit)
T; 0.975 was used

It is to be noted that since the columns under new the RC walls at these grids are short columns, it was necessary to reinforce the existing grade beams at grid 1-B and 7-B for both directions against the seismic design load from the Y direction.

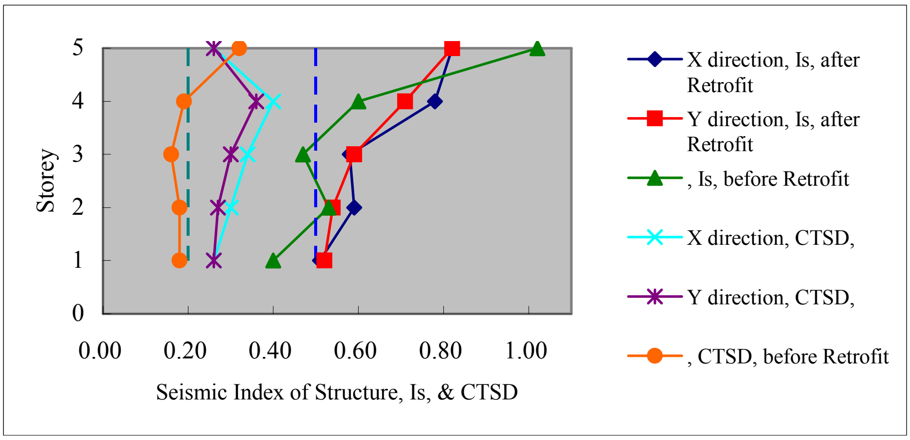


Figure 10-19 Seismic Index of Strucutre, Is, and CTSD after Retrofit

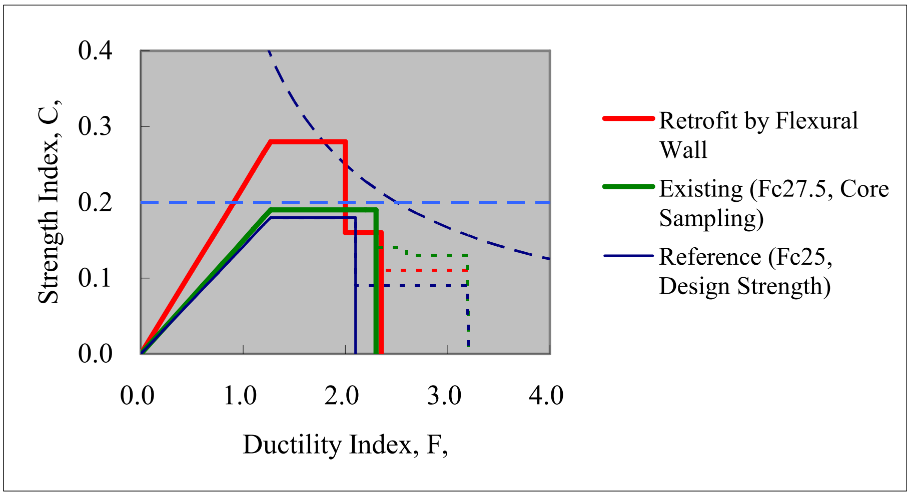


Figure 10-20 Ductility Index and Strength Index in X direction of the 1st Storey

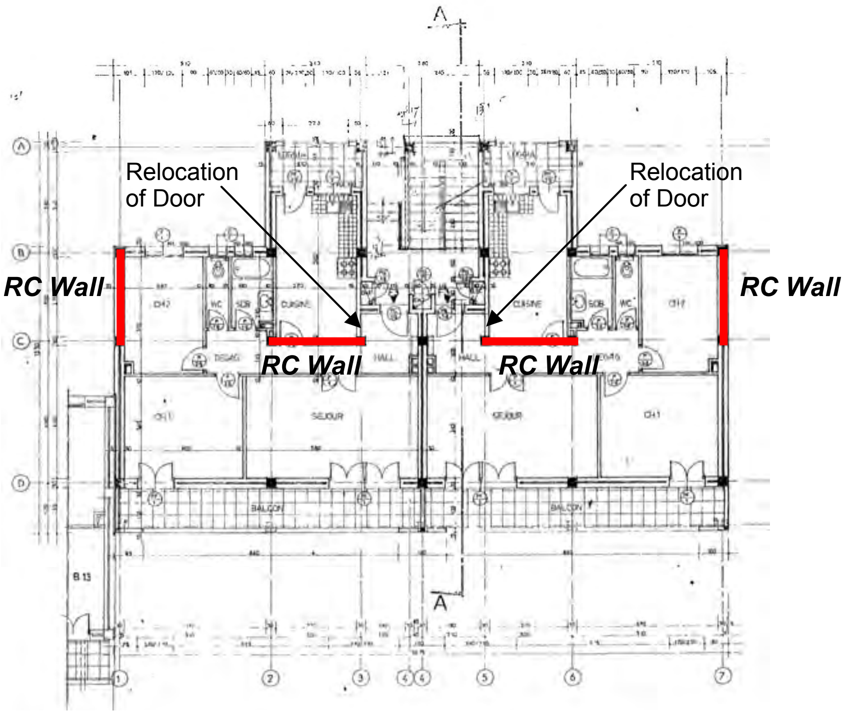
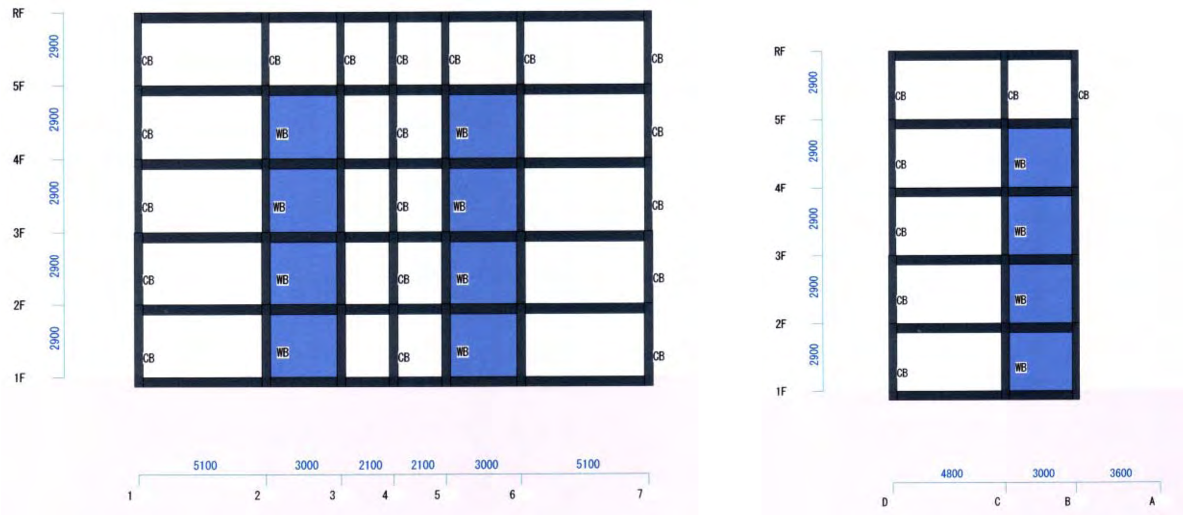


Figure 10-21 Layout of RC Walls for Retrofit at 1st storey to 4th Storey



a) Grid C   b) Grid 1 & Grid 7

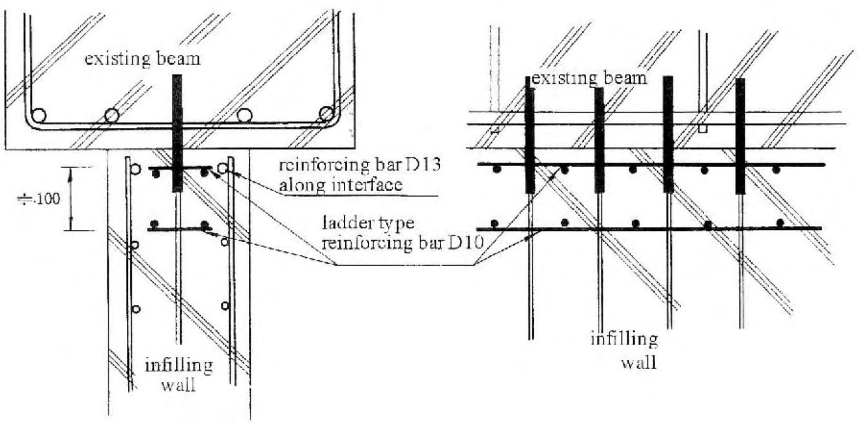
Figure 10-22 Reinforced Concrete Walls for Retrofit

Basic Design of RC Walls for Retrofit

Wall thickness; X direction W150 mm
Y direction W180 mm (1st storey), W150 mm (2nd storey and above)

Reinforcement; W150, D10 mm @200 double layer for vertical and horizontal direction
W180, D12 mm @200 double layer for vertical direction
D10 mm @200 double layer for horizontal direction

Chemical anchor; D16 @200 single (typical for W150)



(Figure 3.1.4 of Reference 1 (English version))

Figure 10-23 Typical Detail of Reinforced Concrete Wall for Retrofit

2) A Two Storey School

(A) General

This building is a typical school of reinforced concrete moment frame, and was designed based on RPA88. Materials used, loading condition and the results of seismic evaluation have been shown in Chapter 9-1-2 (2). The seismic index of structure, Is, in the X direction was low before retrofit, because of the extremely brittle columns and the eccentricity caused by the double layer solid brick walls at grid A.

(B) A Plan and Basic Design for Retrofit

A plan and basic design of 2 cases for retrofit were executed;

Case 1; Retrofit by replacing brick walls and windows, and rectify the extremely brittle columns

This retrofit was done using non-structural elements only.

Case 2; Retrofit using shear walls and wing-walls, and also rectify the extremely brittle columns

A framing elevation with wing-walls for the retrofit is shown in Figure 10-26.

Materials adopted for the retrofit are as follows;

- Re-bar; D10, D12 mm σ = 400 Mpa (400 N/mm^2, yield stress) for walls
- Concrete; f c28 = 20 Mpa (20 N/mm^2, 28 day design strength)

(C) Target of Retrofit

Usage Index = 1.0 was applied. Seismic Demand Index Iso = 0.50, C_TS_D = 0.20 was used.

These are minimum requirements for a retrofit.

(D) Result of Seismic Retrofit

A) Case 1, Retrofit by replacing brick walls and windows at grid A

The seismic index of structure, Is, and C_TS_D after the retrofit are shown in Table 10-28. Columns at grid A have been modified from extremely brittle columns to flexural columns by replacing the walls and windows, and/or providing slits in the standing walls. It is noted that providing slits will require reinforcement of the standing walls against out of plane overturning. The seismic index of structure, Is, has improved in the X direction, from 0.36 to 0.91 at the 2nd storey, and from 0.26 to 0.73 at the 1st storey. $C_{TU}S_D$ at the 1st storey in the X direction was 0.24 and satisfied the minimum requirement but it may be recommended to increase the strength considering its usage.

It is to be noted that the ductility Index, F, is estimated based on a 'Hoop interval @100 mm at the top and bottom of the column. If it is estimated based on a 'Hoop interval @150 mm at the intermediate portion of the column, F, is reduced from 3.2 to 2.6, and, Is, is decreased to approximately 80% of the above value in both the X and Y directions.

Table 10-28 Seismic Index of Structure, Is, and C_TS_D after Retrofit

Building Name:	Constructed Year: 1990 (RPA88)	Date: 2006/6/17
Screening Level: 2	Usage: School	Engineer:

Direction	Storey	C_T	F	Failure Mode	Eo	S_D	T	Is	$C_{TU}S_D$	Judgment
X	2	0.296	3.20	Flexural	0.963	1.00	0.95	0.91	0.30	OK
	1	0.240	3.20	Flexural	0.772	1.00	0.95	0.73	0.24	OK
Y	2	0.467	3.20	Flexural	1.491	1.00	0.95	1.42	0.47	OK
	1	0.391	3.20	Flexural	1.251	1.00	0.95	1.19	0.39	OK

C_{TU} at ultimate of F1 index, $C_T = C \times (n+1)/(n+i)$,
$S_D = 1.0$, T= 0.95

B) Case 2; Retrofit by providing shear walls and wing-walls, and without extremely brittle columns

The seismic index of structure, Is, and C_TS_D after retrofit are shown in Table 10-29.

Typical details of the reinforced concrete wing-wall are shown in Figure 10-26.

- **X direction**

Columns with wing-walls were effective because these columns were flexural columns with a ductility index of 1.5. A wall with columns was not effective, because of the shear type failure. The seismic index of structure, Is, has slightly decreased for the X direction compared with case 1 of the retrofit, from 0.91 to 0.80 at the 2nd storey, and from 0.73 to 0.64 at the 1st storey. '$C_{TU}S_D$' has also decreased from 0.30 to 0.25 at the 2nd storey, and from 0.24 to 0.20 at the 1st storey. This retrofit method was planned for **a study purpose mainly**, and it was recommended to reject shear walls and to provide more wing-walls for the retrofit.

- **Y direction**

The Seismic index of the structure, Is, has slightly decreased compared with case 1 of the retrofit, from 1.42 to 1.14 at the 2nd storey, and from 1.19 to 0.97 at the 1st storey. '$C_{TU}S_D$' has also decreased from 0.47 to 0.37 at the 2nd storey, and from 0.39 to 0.31 at the 1st storey.

Table 10-29 Seismic Index of Structure, Is, and C_TS_D after Retrofit

Building Name:	Constructed Year: 1990 (RPA88)	Date: 2006/6/26
Screening Level: 2	Usage: School	Engineer:

Direction	Storey	C_T	F	Failure Mode	Eo	S_D	T	Is	$C_{TU}S_D$	Judgment
X	2	0.286	1.0	Shear	0.84	1.00	0.95	0.80	0.25	OK
		0.045	1.5	Flexural						
		0.248	3.2	Flexural						
	1	0.193	1.0	Shear	0.67	1.00	0.95	0.64	0.20	OK
		0.035	1.5	Flexural						
		0.199	3.2	Flexural						
Y	2	0.152	1.5	Flexural	1.20	1.00	0.95	1.14	0.37	OK
		0.368	3.2	Flexural						
	1	0.125	1.5	Flexural	1.02	1.00	0.95	0.97	0.31	OK
		0.312	3.2	Flexural						

C_T = C x (n+1)/(n+i) C_{TU} at ultimate of F1 index

C) Comparison of Retrofit for Case 1 and Case 2

The seismic index of the structure and the strength index in the X direction of the 1st storey before and after retrofit are shown in Figure 10-24. The ductility index and the strength index in the X direction of the 1st storey before and after retrofit are shown in Figure 10-25.

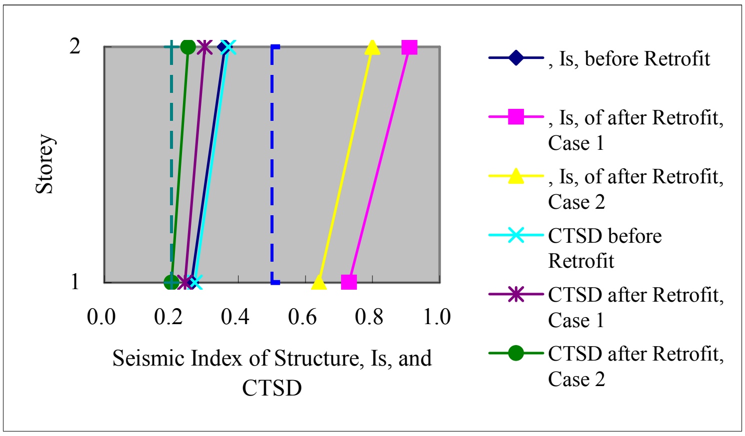


Figure 10-24 Seismic Index of Structure and Strength Index in X direction of 1st Storey

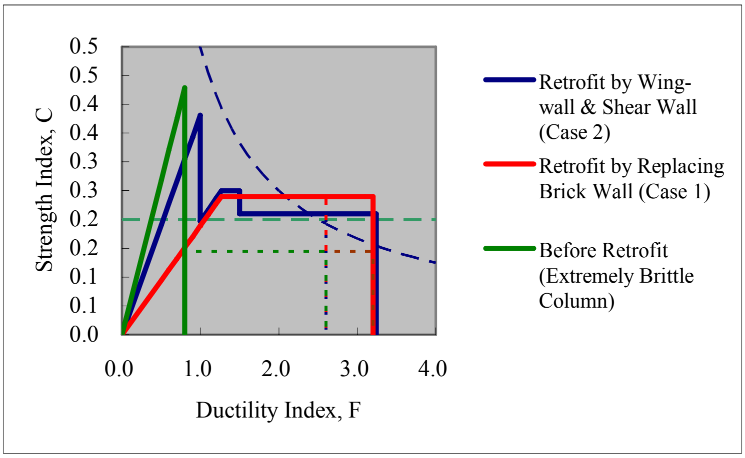
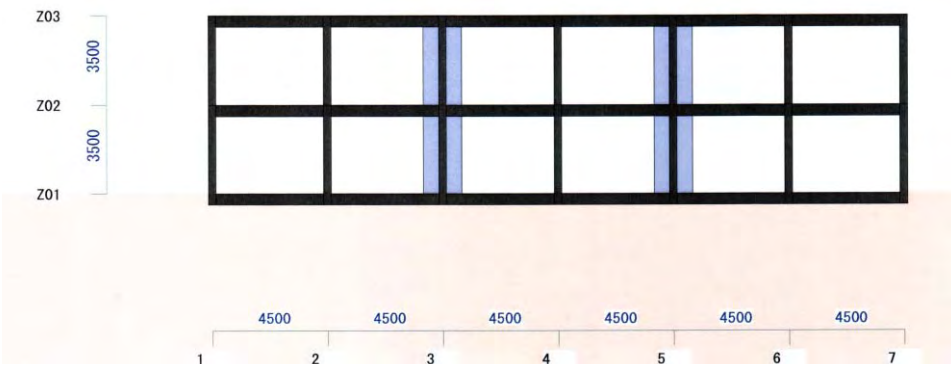
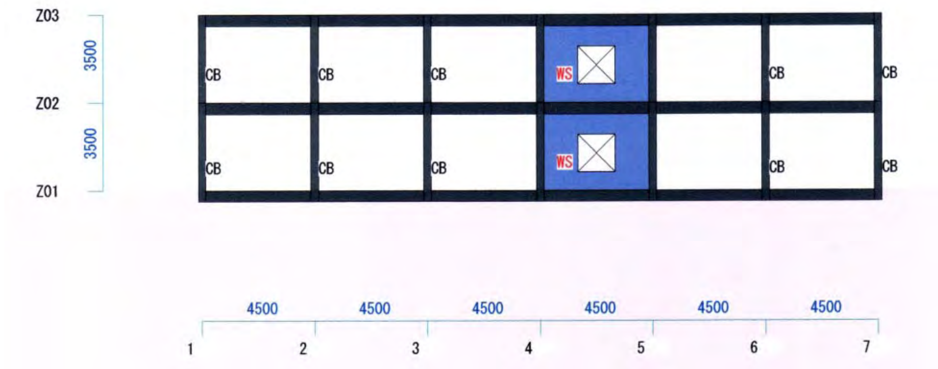


Figure 10-25 Ductility Index and Strength Index in X direction of 1st Storey



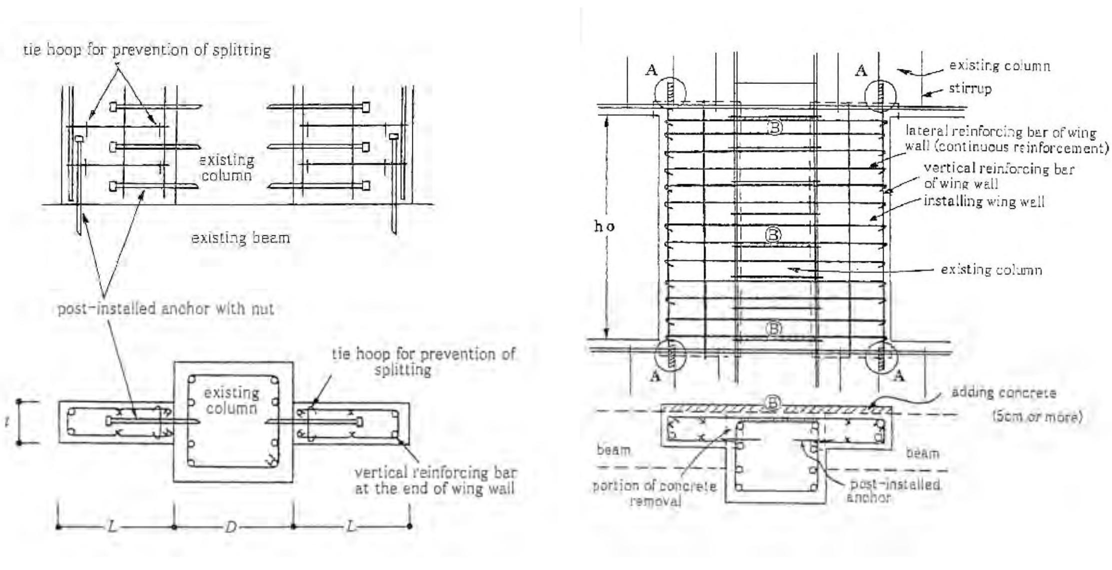
a) Wing-walls (thickness = 200 mm)



b) Walls with Columns at Both Sides (thickness = 150 mm)

Figure 10-26 Framing Elevation with Walls for Retrofit (Case 2)

Basic Design of RC Wing-Wall for Retrofit
Wall thickness; W200 mm
Reinforcement; D10 mm @200 double layer for vertical and horizontal directions
Chemical anchor; D16 @200 single (typical)



(Figure 3.2.4-1 & 3.2.4-2 of reference 1)

Figure 10-27 Typical Details of Reinforced Concrete Wing-wall

3) Pierre and Marie Curie Center Chemo-Therapy Building, Mustapha Hospital

(A) General

This hospital has been nominated as a strategically important building. This hospital is a reinforced concrete moment frame structure, and was designed based on RPA88. Refer to Chapter 9-1-2 (3), for materials used, loading conditions and the results of the seismic evaluation of this building. Horizontal strength at the 1st storey only was recommended to increase for both directions.

(B) A Plan and Basic Design for the Retrofit

A plan and basic design of 3 cases for the retrofit at the 1st storey only was executed. The retrofit plan at the 1st storey by following 3 different methods is shown in Figure 10-31.

Case 1; Retrofit by providing shear walls for the X and Y directions.
Case 2; Retrofit by providing wing-walls for the X and Y directions.
Case 3; Retrofit by providing jackets for the columns.

Materials adopted for the retrofit are;

Re-bar; σ = 400 Mpa (400 N/mm^2, yield stress) for main bars and wall re-bars
σ = 235 Mpa for hoop (ø 8 mm)
Concrete; f c28 = 27Mpa (27N/mm^2, design strength at 28 days)

(C) Target of the Retrofit

Usage Index 1.5 was applied. Seismic Demand Index Iso = 0.50x1.5=0.75, C_TS_D = 0.20 x 1.5 = 0.30 was used. These requirements are the minimum, considering that this hospital is a strategically important building.

(D) Results of the Seismic Retrofit

A) Case 1, Retrofit using RC Walls

The horizontal strength for both directions was increased, but the seismic index of structure, Is, was decreased because of the ductility index of 1.0, which was because of the shear wall.

B) Case 2, Retrofit using Wing-walls

The seismic index of the structure, Is, and C_TS_D after the retrofit are shown in Table 10-30. C_TS_D was increased by the wing-walls, but the seismic index of the structure, Is, was decreased because of the ductility index of 1.5, which was because of the columns with wing-walls.

Table 10-30 Seismic Index of Structure, Is, and C_TS_D after Retrofit (Case 2)

Storey	X direction		Y direction	
	Is	C_TS_D	Is	C_TS_D
3	1.74	0.85	1.72	0.84
2	1.15	0.47	1.13	0.46
1	0.54	0.46	0.54	0.45

S_D= 1.11, T = 0.95

C) Case 3, Retrofit using Column Jacketing

The seismic index of the structure, Is, and C_TS_D after retrofit are shown in Table 10-31 and Figure 10-28. The standard detail for the column jacketing is shown in Figure 10-30.

C_TS_D has increased from 0.24 to 0.35.

The seismic index of the structure, Is, has increased from 0.72 to 1.06 in the Y direction. This was possible since jacketing columns has produced a ductility index of 3.2, which was the same as that of the original. S_D also has increased from 1.0 to 1.1 due to the stiffness increase at the 1st storey.

Table 10-31 Seismic Index of Structure, Is, and C_TS_D after the Retrofit (Case 3)

Storey	X direction		Y direction	
	Is	C_TS_D	Is	C_TS_D
3	1.74	0.85	1.72	0.84
2	1.15	0.47	1.13	0.46
1	1.07	0.35	1.06	0.35

S_D =1.11, T 0.9

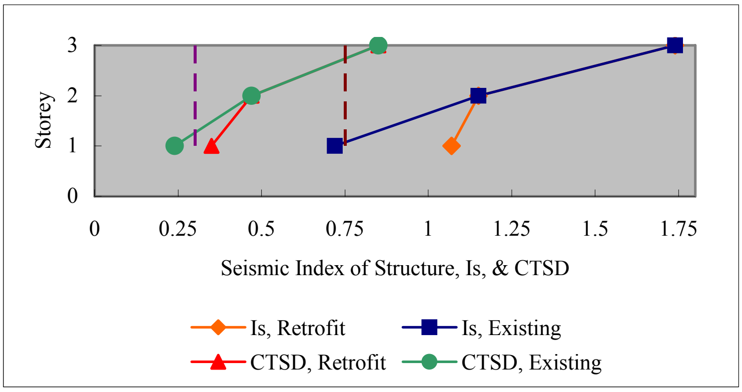


Figure 10-28 Seismic Index of Structure, Is, and, C_TS_D, after the Retrofit using Column Jacketing

D) Comparison of Retrofit Methods

The relationship of the strength index and the ductility index in the X direction of the 1st storey before and after the retrofit is shown for the 3 cases in Figure 10-29.

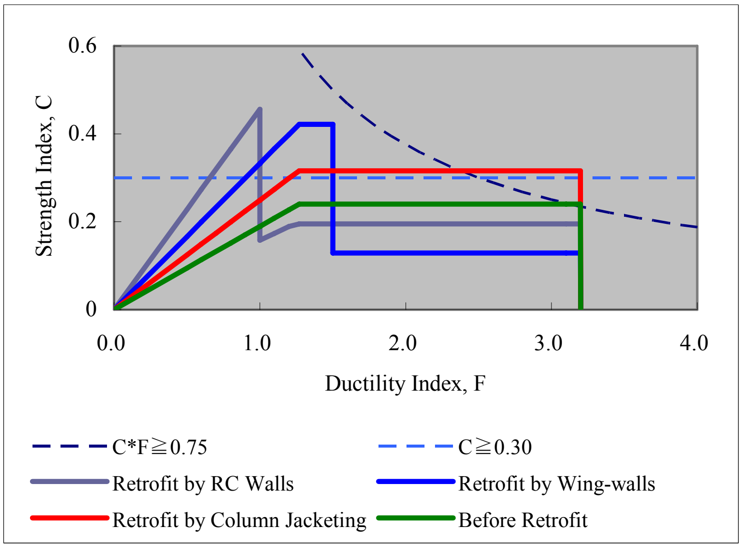
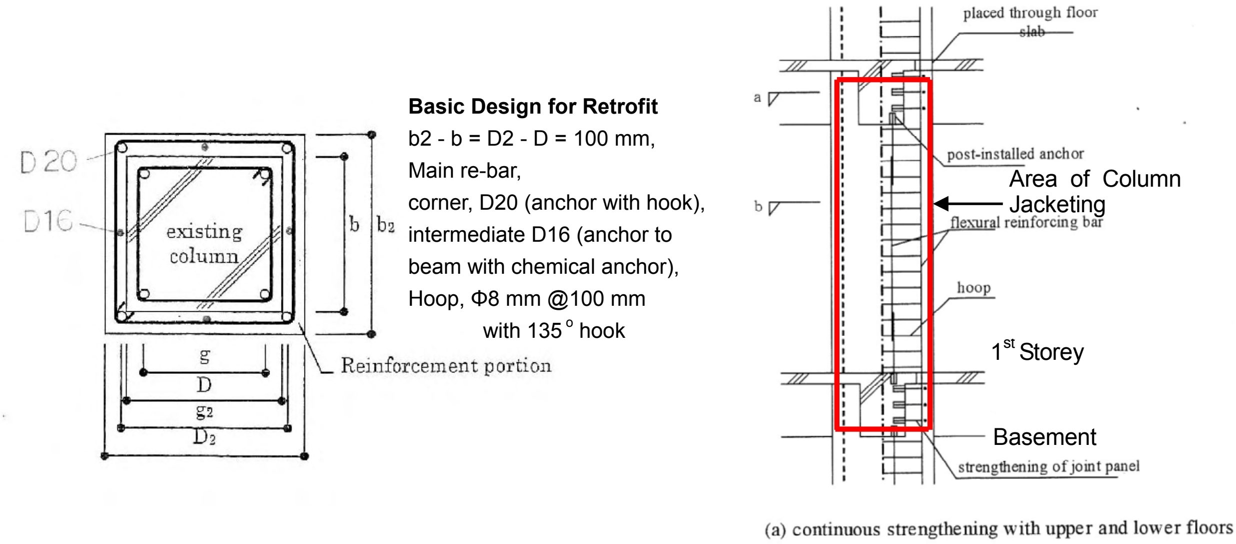
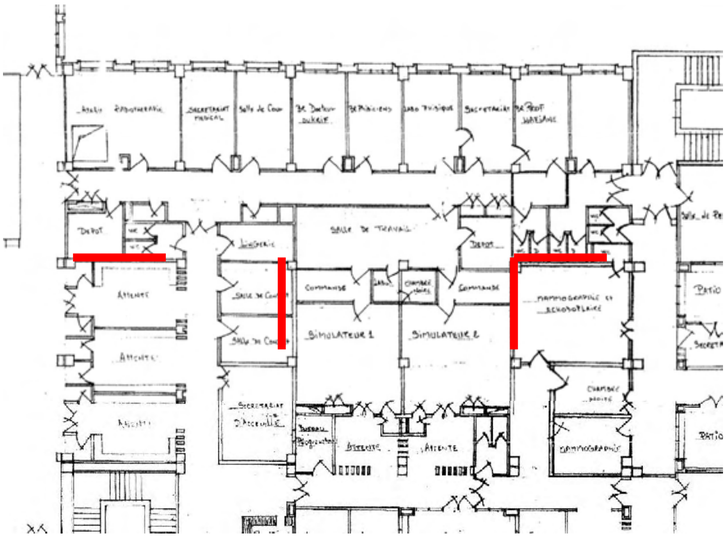


Figure 10-29 Relationship of the Strength Index and Ductility Index in the X direction of the 1st Storey



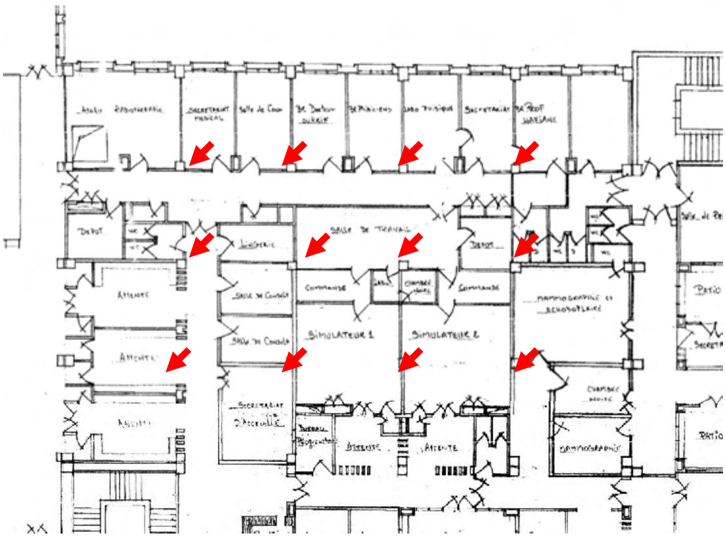
(Figure 3.3.4-2 and 3.1-4 of English version of Reference1)

Figure 10-30 Standard Detail of Column Jacketing



a) Shear Walls at 1st Storey

b) Wing-walls at 1st Storey



c) Column Jacketing at 1st Storey

Figure 10-31 Retrofit Plan at the 1st Storey using 3 Different Methods

(4) Recommendations

1) Target for Retrofit

As explained in Chapter 10-3-3 (2), the following seismic Demand Index, Iso, and Cumulative Strength Index x Irregularity Index, $C_T S_D$ are recommended as a target of retrofit for existing RC buildings in Algiers;

Iso = (0.50 ~ 0.60) ZGU

$C_T S_D \geqq (0.20 \sim 0.30)$ ZGU

U: Usage Index, 1.0, 1.25, and 1.5

Z = G = 1.0 for typical case

2) Measures for Retrofit

As shown in Chapter 10-3-3 (3), providing RC walls, wing-walls, and column jacketing are the main measures for retrofitting of RC buildings. Materials for these measures are commonly used in Algiers and no special workmanship is required except for the chemical/mechanical anchors. It is also useful to replace existing brick walls to prevent brittle failure of short columns of the school building. It is essential to provide suitable structural elements with a combination of strength and ductility subject to the building structural type for the retrofit.

3) Seismic Design Code and Retrofit

Through seismic evaluation and basic retrofit design for existing apartment houses, the following conclusions were reached;

(A) Non-engineered apartment houses built with low strength concrete can be expected to have an Is in the range of 0.13 to 0.15 and therefore should be demolished, since a seismic retrofit will be technically difficult and the cost will be prohibitive. A non-engineered building built with standard strength concrete and having an Is of 0.25 or more may be technically possible to retrofit but the cost will be great.

(B) Generally, an apartment house designed using RPA81 (83) or 88 will require seismic retrofit.

(C) An apartment house designed using RPA99, might require a seismic evaluation to determine if retrofit is necessary.

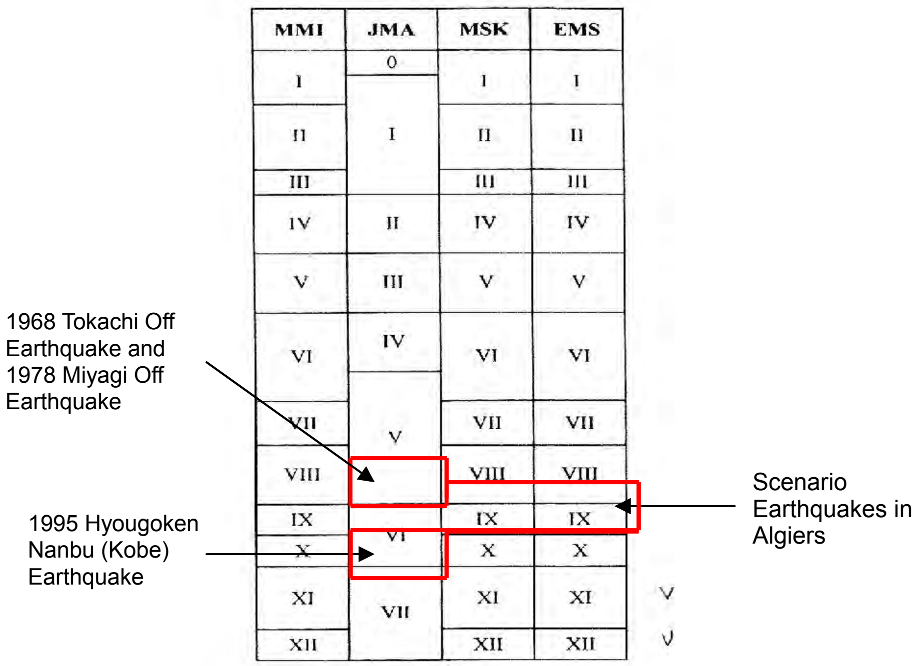
(D) An apartment house designed using RPA99 ver 2003 and constructed with reasonable quality materials and workmanship will have reasonable seismic capacity.

In any case, concrete strength will govern the seismic capacity of a building. Therefore, it is recommended to evaluate the actual concrete strength from core sampling or an equivalent reliable method.

Appendix 1 Seismic Index of Structure, Is, and C_TS_D, and Seismic Intensity and Earthquake Damage

(1) Estimated Seismic Intensity in Algiers

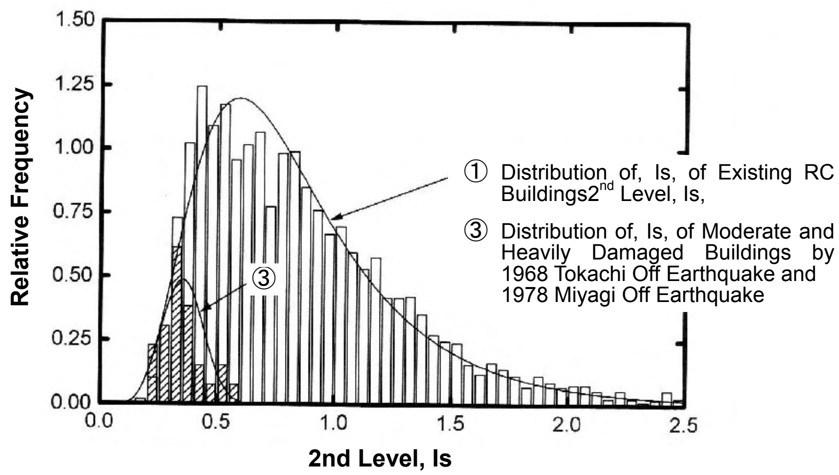
Estimated EMS seismic intensity in Algiers by scenario earthquakes is in the range of 8 to 9, and it is recommended to implement measures to prevent heavy structural damage and/or collapse of buildings due to the forces of an event of EMS seismic intensity 9.



(Figure 2-1 of 'The vulnerability assessment and the Damage Scenario in Seismic Risk Analysis' by Dr. S. Giovinazzi)

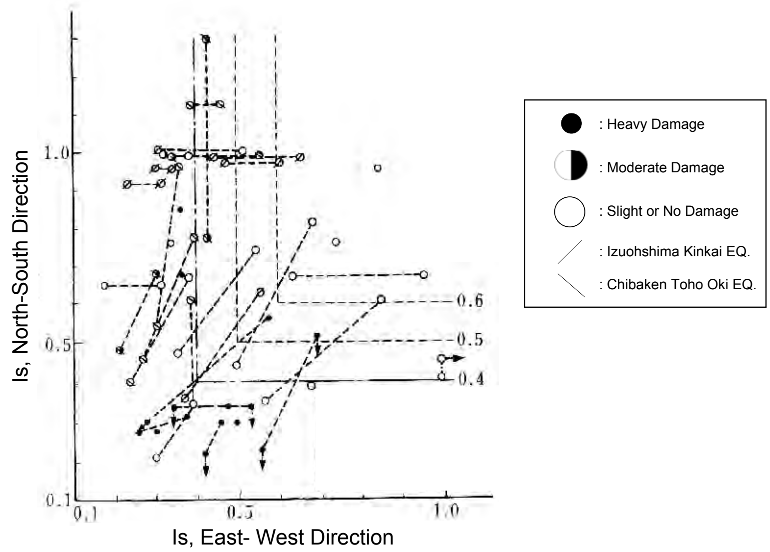
Figure 10-A1 Comparison between EMS (MSK) and JMA

(2) Seismic Index of Structure, Is, and Earthquake Damage



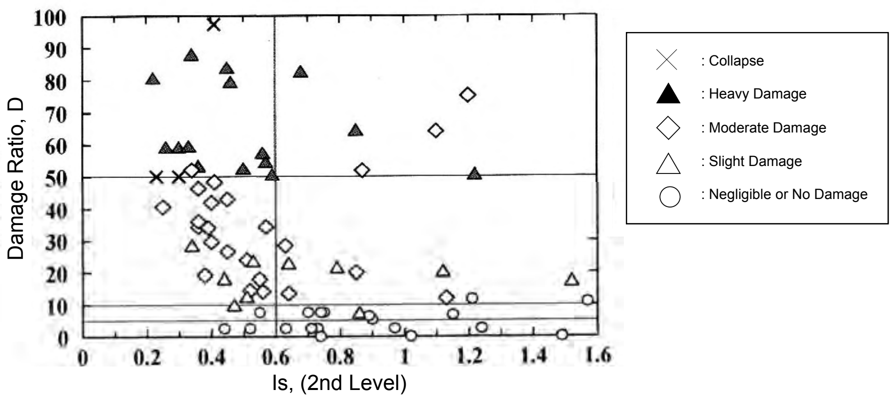
(Figure A5.2-3 of Reference1)

Figure 10-A2 Seismic Index of Structure, Is, and Earthquake Damage in Japan



(Figure A5.2-2 of Reference1)

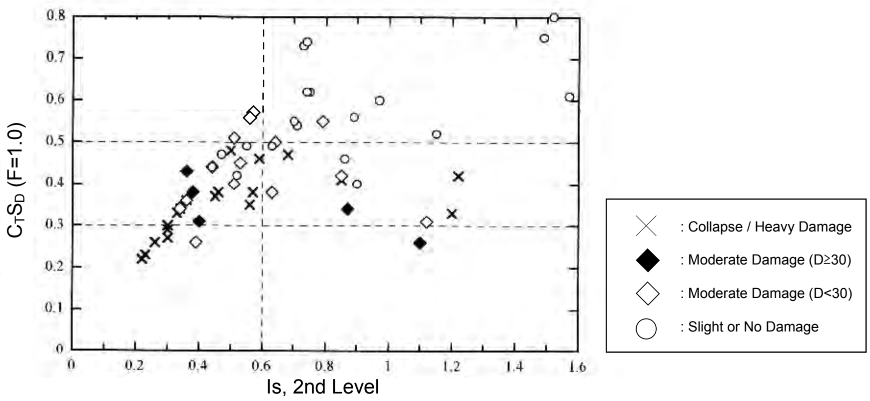
Figure 10-A3 Seismic Index of Structure, Is, and Earthquake Damage



1995 Kobe Earthquake (Figure A5.2-4 of Reference1)

Figure 10-A4 Seismic Index of Structure, Is (2nd Level), and Damage Ratio of Buildings due to

(3) Seismic Index of Structure (2nd Level), Is, and C_TS_D, and Buildings Damaged



Kobe Earthquake (Figure A5.2-5 of Reference1)

Figure 10-A5 Seismic Index of Structure (2nd Level), Is, and C_TS_D and Buildings Damaged by 1995

10-4 Infrastructure and Lifelines

10-4-1 Infrastructure

The infrastructure includes basic facilities such as roads, bridges, ports and airports, all of which enable a population center to function properly as a base of transportation.
Even though all contingency plans for rescue and relief efforts have been well prepared, if the infrastructure is destroyed by, for example, a massive earthquake, such plans will not be able to be put into effect. In this respect, it is crucial to maintain and secure the infrastructure for smooth relief efforts.

This section gives a summary account of the extent of damages to the infrastructure caused by earthquakes in the past, and outlines measures and steps which could contribute to the design of future disaster prevention plans.

(1) Roads

A road network is an important part of the infrastructure to protect human life and to secure economic activities. Once it has lost its function, emergency relief efforts and rehabilitation activities in disaster stricken areas will be considerably disturbed. What is more, the damage to roads will have an impact, not only on the region directly hit by the disaster, but also on the surrounding regions. In this sense, it is indispensable to enhance the earthquake safety of the road network, and attention must be paid to prevent the network system from any disconnection.

1) Characteristics of Road Damage

Characteristics of road damage from earthquakes can be categorized as shown in Figure 10-32.

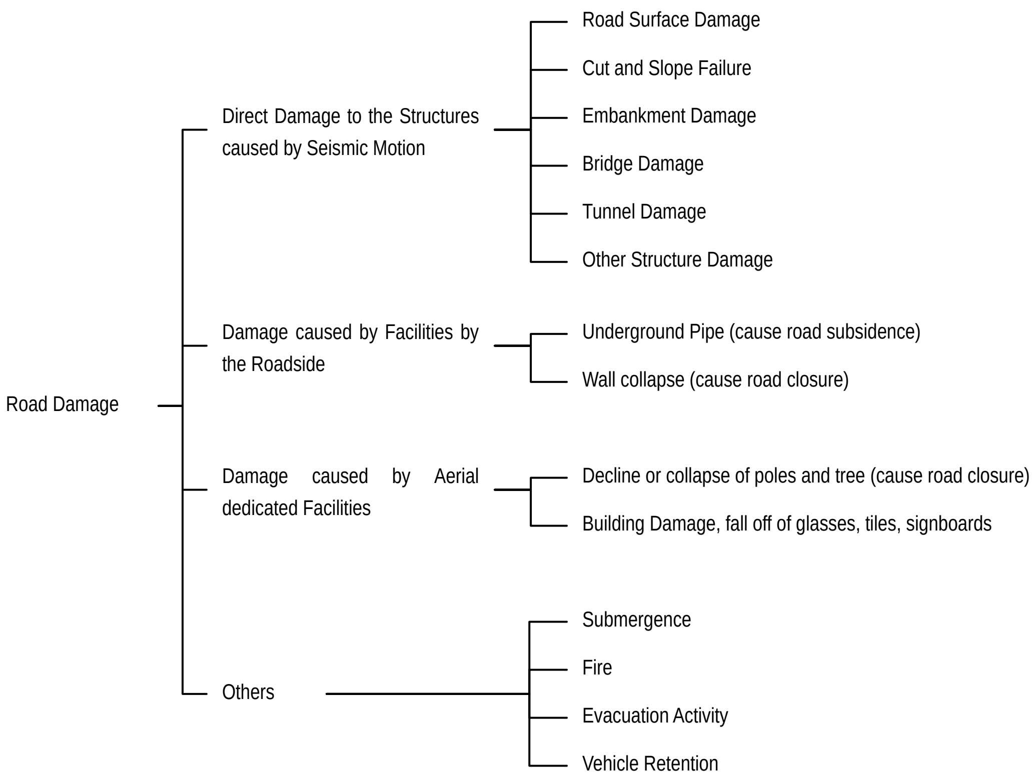
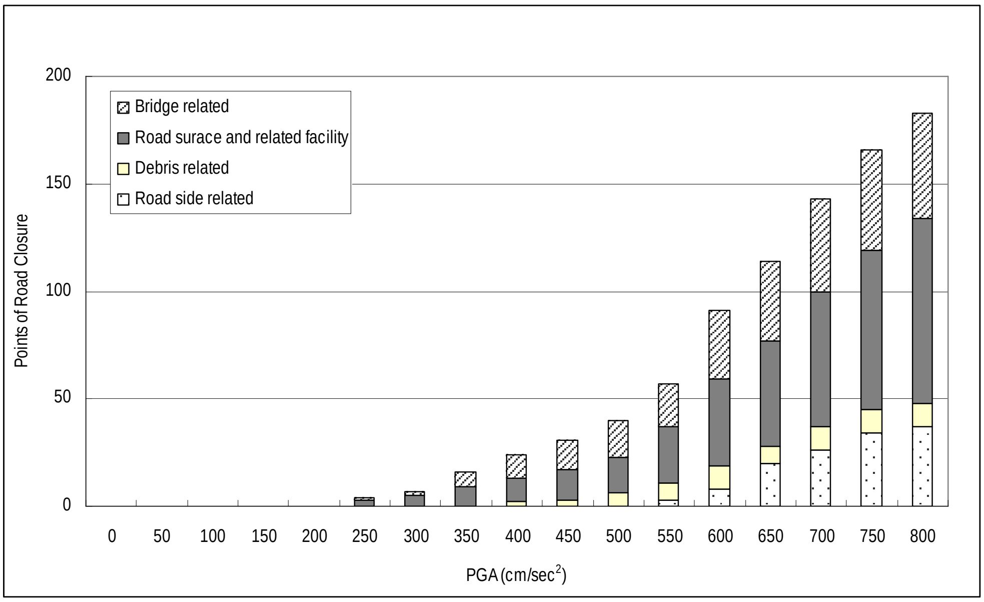


Figure 10-32 Characteristics of Road Damage caused by an Earthquake

The Kobe Earthquake in 1995 caused a detrimental effect on traffic at 230 points of the roads under the management of the national or municipal governments, 67 % (155 points) of which were due to damage to bridges and 33% (77 points) to damage to road structures. Of the damages to road structures, 62% (48 points) were attributable to damage to roadside structural objects, such as utility polls and buildings. According to a research survey concerning the relationship between road damage and the ground acceleration, roads begin to be ruined when the seismic acceleration exceeds 250gal, and the number of instances of damage on roads sharply increases when the seismic acceleration exceeds 600 gal (see Figure 10-33).



Source: Japan Road Association, 2002

Figure 10-33 Relationship between Road Damage and Ground Acceleration

2) Recommendations / Measures to Strengthen and Quake-proof the Road Network

Since a road network includes bridges and other node facilities, factors other than roads must be taken into account in considering possible measures to strengthen the network or make it quakeproof: for example, any damage to a bridge will directly disrupt the function of the road network. Therefore, it is necessary, when planning to improve the road network or make it quakeproof, to draw up and put into effect a plan which also covers bridges and other node facilities.

(2) Bridges

As shown in the previous section, in order to make the function of a road network secure, it is crucial to prevent damage to bridges.

Hence, where bridges which seem to be highly or moderately likely to fall if an earthquake of various degrees happens (High Probability and Moderate Probability as shown in Table 10-32), careful investigations must be conducted into the ground conditions and the structures of the bridges in question.

Table 10-32 Summary of Damage Estimation for Bridges

Class of Damage Grade	Khair al Din	Zemmouri
High Probability	3	4
Moderate Probability	19	7

1) Characteristics of Bridge Damage

Collapse of bridges will be detrimental, in particular, to the road network, and their reconstruction will take a long time. Bridge damage observed in the events of earthquakes occurring in the past include falling girders, damage to or collapse of reinforced concrete piers due to differences in the amount of rebar, damage to foundations and their surroundings, and deformation of abutments (Photo 10-1: Collapsed flyover after the Kobe Earthquake).

Extracted from Kobe-city website (http://www.city.kobe.jp)

Photo 10-1 Flyover damaged by Strong Motion

The damage to bridges seems largely attributable to the poor aseismic strength of their structures and ground deformation caused by liquefaction. In line with this, the following sections will introduce recommended measures to reinforce the seismic strength of a bridge structure itself and to improve the relevant ground.

2) Recommendations / Measures for to Strengthen and Quake-proof Bridges

A bridge structure can be divided into two parts: the superstructure including girders, and the substructure including piers. Various methods to improve the seismic strength have been suggested in recent years. This section provides some representative methods.

Figure 10-34 shows typical strengthening methods widely adopted in Japan.

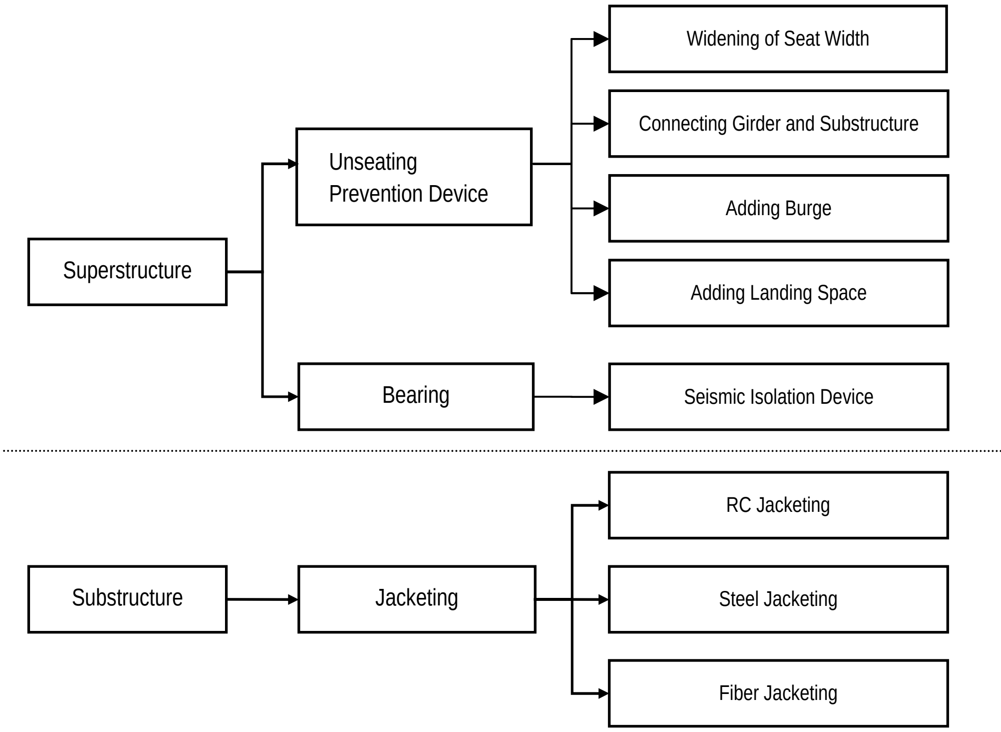


Figure 10-34 Methods of Increasing Seismic Strength of Bridge Structures

In Japan, highway bridges are designed in conformity with the "Specifications for Highway Bridges", which were drawn up in 1923 so bridges in Japan would be able to resist earthquakes equivalent to the Great Kanto Earthquake (M7.9). Despite this, the Kobe Earthquake (M7.2) damaged a large number of bridges because it generated, rather unexpectedly, a horizontal seismic force. Following this earthquake, the said specifications were revised and reinforcing work was conducted on a large number of bridges.

(A) Measures to Make Superstructure Quakeproof

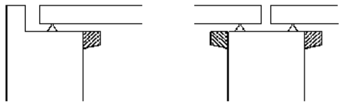
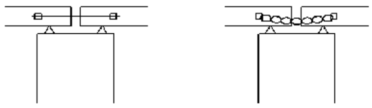
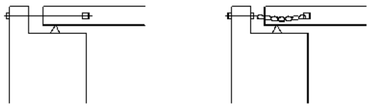
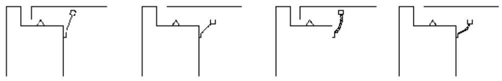
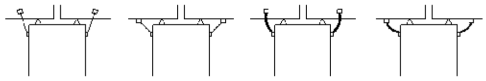
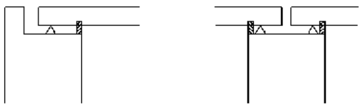
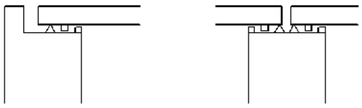
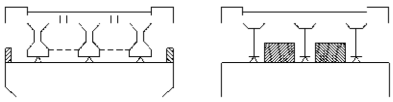
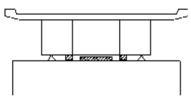
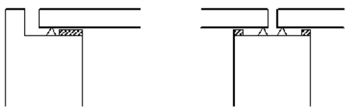
A) Unseating Prevention System

As stated above, the worst-case scenario among damage to bridges is the unseating (falling) of girders. Prevention of the unseating will contribute to rescue efforts.

A basic measure to enhance earthquake safety concerns prevention of the superstructure from falling: there are three specific preventive measures as shown below.

- Extension of seat width on pier caps
- Control of relative displacement between girder and pier/abutment
- Control of relative displacement between girder and adjoining girder

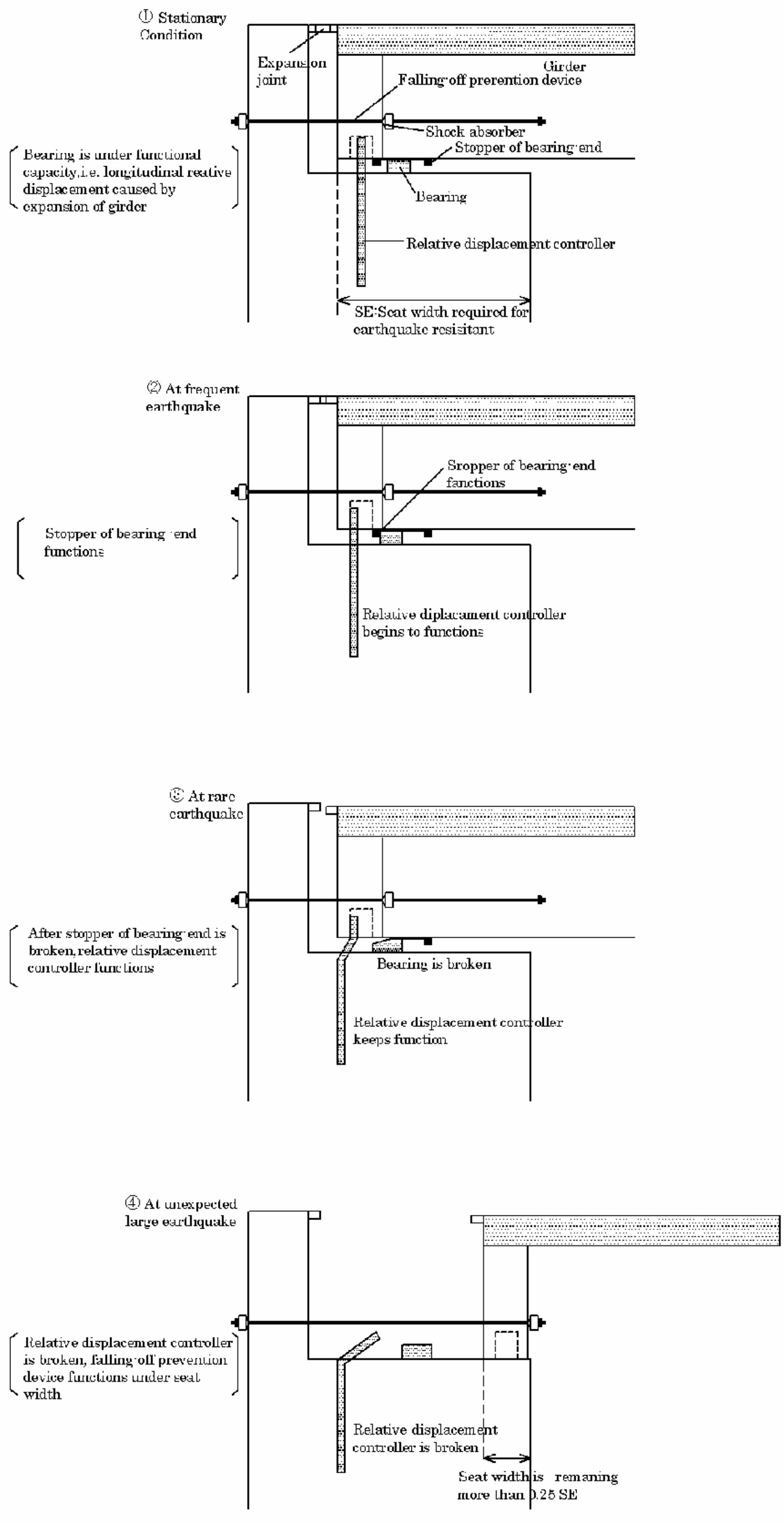
Figure 10-35 shows a schematic drawing of "Unseating Prevention Systems" widely used in Japan.

Direction	Category			Item	Material	Schematic Configration	Remark
Regarding longitadinal direction	Widening of Seat width				R/C or Steel plate		Adding Bracket
Regarding longitadinal direction	Fall-off prevention device			Connecting device between girder and adjoining girder	P/C Strand or Steel chain		
Regarding longitadinal direction	Fall-off prevention device and Relative displacement control	Connecting girder and substructure	Abutment	Connecting girder and parapet	P/C Strand or Steel chain		
Regarding longitadinal direction	Fall-off prevention device and Relative displacement control	Connecting girder and substructure	Abutment	Connecting girder and Substructure	P/C Strand or Steel chain		Attach to girder side or under surface
Regarding longitadinal direction	Fall-off prevention device and Relative displacement control	Connecting girder and substructure	Pier	Connecting girder and Substructure	P/C Strand or Steel chain		Attach to girder side or under surface
Regarding longitadinal direction	Fall-off prevention device and Relative displacement control	Bulge		Bulge on substructare	R/C or Steel plate		
Regarding longitadinal direction	Fall-off prevention device and Relative displacement control	Bulge		Conbination of bulge	R/C or Steel plate		
Transrerse direction	Fall-off prevention device and Relative displacement control	Bulge		Bulge on substructure	R/C or Steel plate		Outside or inside of girder
Transrerse direction	Fall-off prevention device and Relative displacement control	Bulge		Conbination of bulge	R/C or Steel plate		
Adding of landing space				Landing space on substructure	R/C or Steel plate		

Source: Japan Road Association, 2002

Figure 10-35 Typical Samples of “Unseating Prevention System”

Figure 10-36 provides a summary of diagrams of effects of the measures in accordance with earthquake intensity.



Source: Japan Road Association, 2002

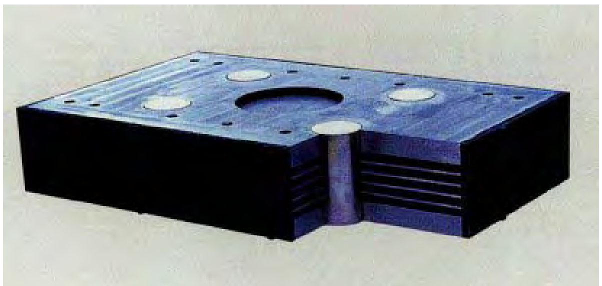
Figure 10-36 Effects of Measures in accordance with Various Degrees of Earthquake Intensity

Figure 10-37 shows a sample installation of the damper controlling relative displacement between adjoining girders using elastic materials in which relative displacement between the girder and adjoining girder is controlled by a damper with specially equipped viscous material.

Figure 10-37 Example of Displacement Controlling by Damper

B) Bearings

Installation of bearings to seismic isolation devices is very effective to control horizontal movement of girders. Figure 10-38 gives a picture of a seismic isolation device and Figure 10-39 shows different behaviors of a seismic isolation device and, as a comparison, an ordinary bearing.



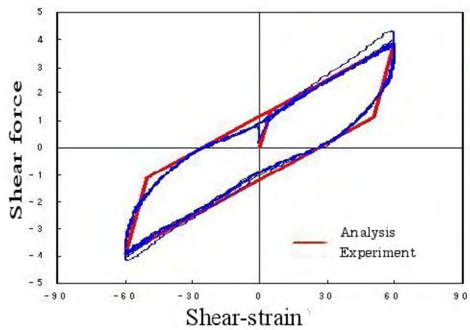


Figure 10-38 A Seismic Isolation Device (Lead Rubber Bearing)

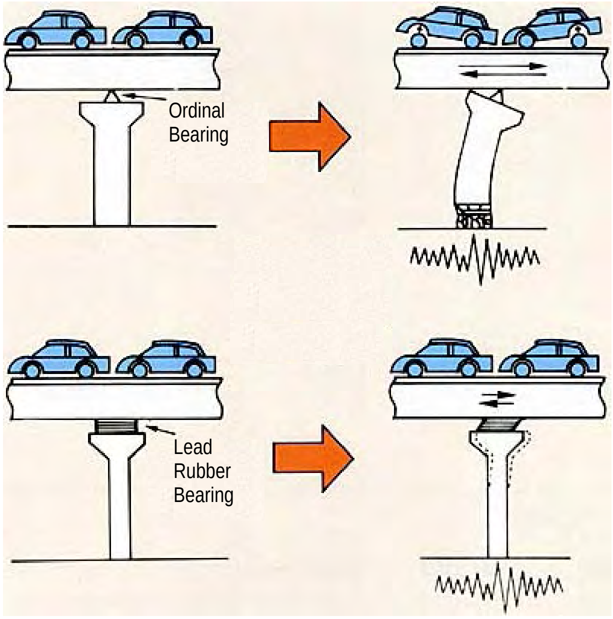


Figure 10-39 Behavior of Seismic Isolation Device

(B) Measures to Make Substructure Quakeproof

A typical method of improving seismic strength of the substructure is the method called "Jacketing." The idea of this method is to wrap various materials around the pier to make this substructure quakeproof. In Japan, three types of jacketing methods are adopted.

- "RC Jacketing", where rebars are installed and then additional concrete is poured around the existing pier to construct an additional wall (see Figure 10-40).

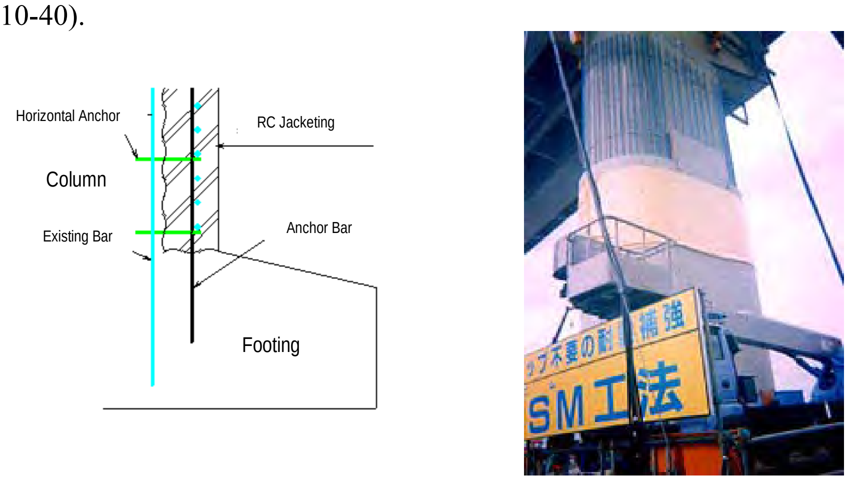


Figure 10-40 RC Jacketing Method

- "Steel Jacketing", where a steel plate is wrapped around the existing pier and the gap between the pier and the plate is filled with mortar (see Figure 10-41)

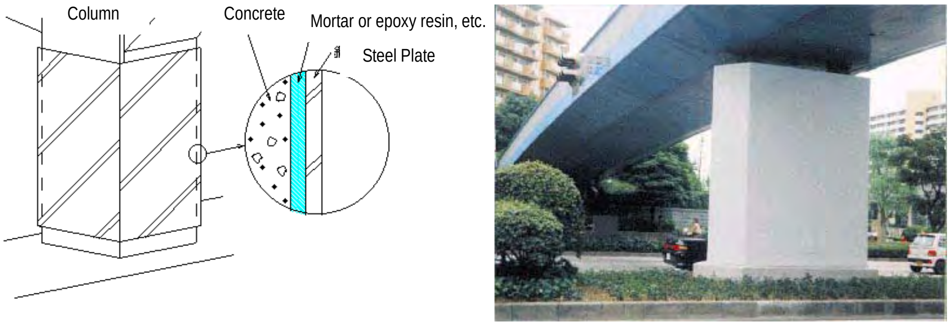


Figure 10-41 Steel Jacketing Method

- "Fiber Jacketing": fiber strings or sheets are wrapped around the existing column, and a finisher is applied on top of that (see Figure 10-42). This method is effective in preventing columns from buckling.

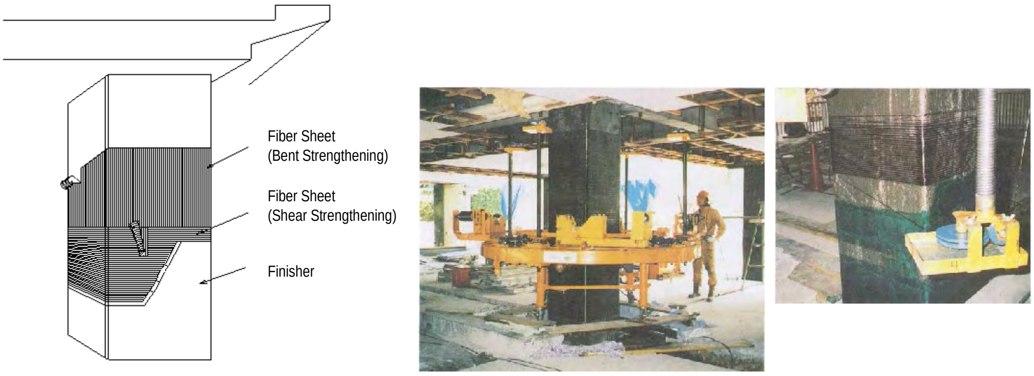


Figure 10-42 Fiber Jacketing Method

3) Ground Improvement

If liquefaction occurs underneath bridges, horizontal and / or vertical displacement of the ground occurs, which is likely to have a negative impact on the bridges, such as deformation of the piers and subsidence of the abutments. Such deformation leads to the malfunctioning of the bridges. Therefore, detailed geotechnical investigations must be conducted and, if necessary, certain measures must be also be taken for bridges built on places where the ground is considered to be highly susceptible to liquefaction.

Figure 10-43 gives a list of steps to reduce or prevent liquefaction.

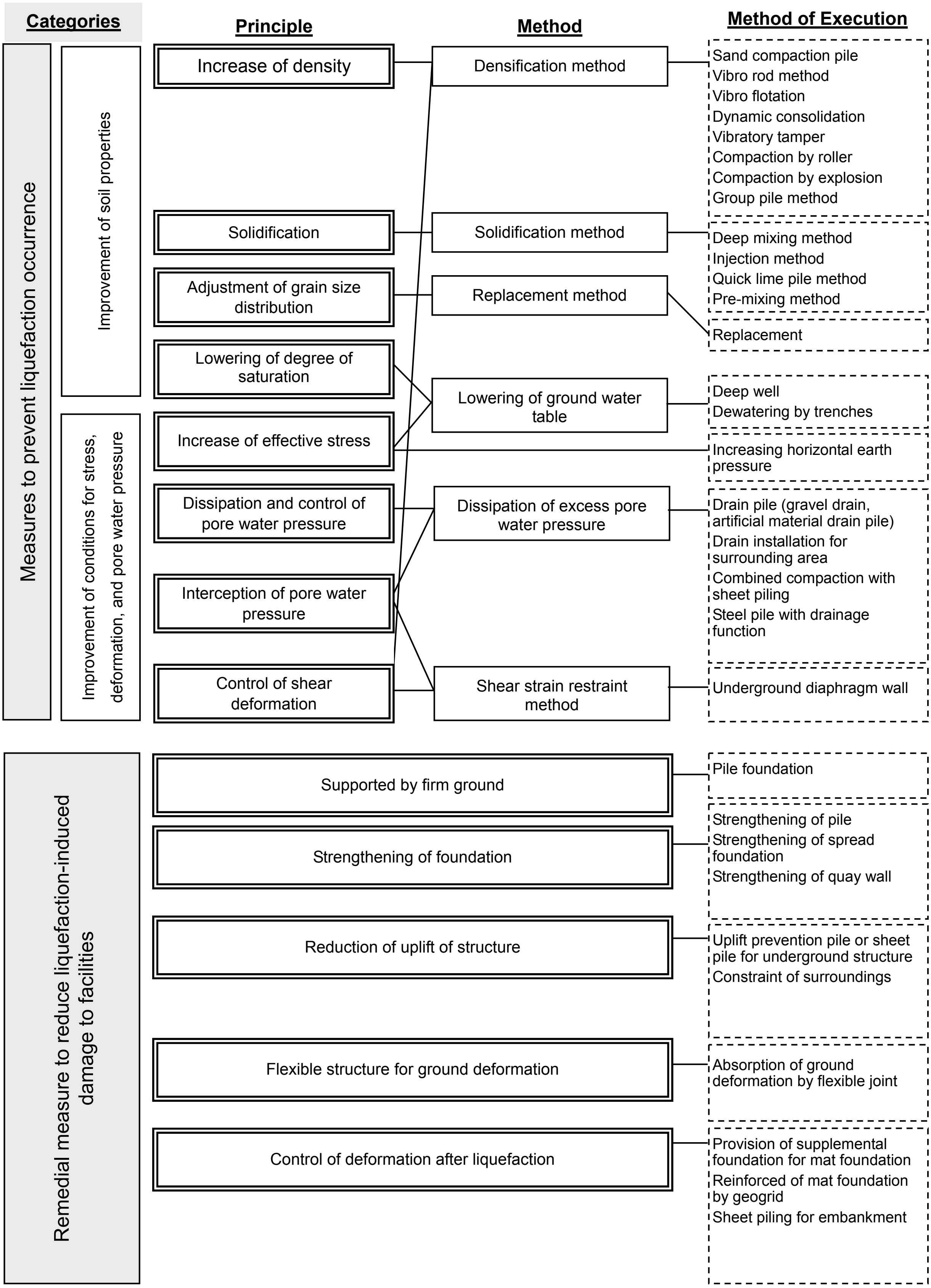


Figure 10-43 Summary of Measures to reduce or prevent Liquefaction

(3) Ports

Port facilities, as shown below, play a crucial role in post-earthquake activities, so that they must maintain their functions:

- Acceptance of relief goods from abroad by sea
- Transport of relief goods to disaster stricken areas
- Temporary storage of relief goods
- Temporary storage of debris and garbage

Port facilities need to have proper quakeproof structures so as to function as terminals promptly after an earthquake occurs. At the same time, not only wharves, storage and landing facilities but also access routes to the port must be studied.

1) Characteristics of Port Damage

In the event of earthquakes in the past, quite a few port facilities were subject to liquefaction. The nature of damage observed in the past is listed as follows:

- Cracks and subsidence of piers as a result of liquefaction
- Fall of gantry cranes

Concerning the Kobe Earthquake in 1995, the following kinds of damage were reported:

- Most damage to the port facilities resulted from soil liquefaction and lateral spreading. A large number of the gravity foundations of the quay wall caissons were turned upside down or slid towards the sea. The lands immediately behind the caissons sank as much as 3 meters in depth, and the depth of ground settlement was shallower as one traveled inland (see Photo 10-2). While structural objects supported by piles remained at the original levels, neighboring grounds subsided substantially. Significant quantities of sand were ejected due to liquefaction, covering large parts of the pavements. The majority of gantry cranes were damaged, and some of them collapsed due to displacement of quay wall caissons.

Extracted from Kobe-city website (http://www.city.kobe.jp)

Photo 10-2 Settlement behind a Quay Wall

- As for the gantry cranes that were demolished (see Photo 10-3), the legs and cross-beams were buckled and the wheels were broken down. The degree of damage to the buckled legs and cross-beams varied, but the primary cause was the horizontal movement of the caissons. Some cranes were derailed from the tracks, while others fell down due to structural damage caused by inertial forces of the earthquake.

Extracted from Kobe-city website (http://www.city.kobe.jp)

Photo 10-3 Collapsed Gantry Crane

- Displacement of quay wall caissons was counted as major damage to the port facilities, and attributable to several phenomena. Earthquake accelerations affecting the massing sand-filled caissons brought a great horizontal force which might be greater than the sliding resistance of the base. It seemed likely that the earthquake accelerations generated the rocking motion of the caissons possibly exceeding the bearing pressure at the toe of the base, and consequently destabilized the situation further.
- Damage to piers and their quay walls, other than those described above, was also confirmed. At some old port facilities, in particular, those located in the south of the central part of Kobe city such as Hyogo Pier, large parts of the piers were submerged as a result of serious ground subsidence, whose magnitude was found to be more than 2 - 3 meters. Quite a few warehouses and other facilities were also submerged, and seriously damaged.

2) Recommendations / Measures to Make Port Facilities Quakeproof

To secure the safety of port facilities, it is necessary to take appropriate measures to increase the seismic resistance of the Algiers port. In order to maintain its stable capability in ocean transportation, the port is required to be operated on a continuous basis even if a great earthquake occurs.

In this sense, harbor ports are regarded as crucial facilities for disaster prevention planning, every measure necessary for strengthening seismic resistance should be taken.

(A) Development of Seismic Resistant Quays

A damage estimation suggests that, in the event that an earthquake as great as the Khair al Din or the Zemmouri cases occurs, the central and southern parts of the Algiers port will be seriously damaged. As for the facilities within the premises of the Algiers port, it is necessary to draw up a plan to construct seismic resistant quays so as to make the transportation function secure and ensure that it is possible to handle the movement of relief goods. Even so, it seems unrealistic, in consideration of the time and cost constraints, to make all quays quakeproof. Thus, it is recommended that, while paying attention to the existing development plans, at least one seismic resistant quay should be created in the port.

(B) Improvement of Bridges and Roads Leading to the Port Facilities

An access road connecting the seismic resistant quay to the main roads should be made quakeproof so that damage caused by any disasters will not obstruct the smooth transportation of relief goods. In order to prevent damage to the road network, consideration should be given to the need of conducting seismic diagnostic examinations and retrofitting structural objects related to the bridges.

(4) Airports

When an area is stricken by an earthquake the airport facilities are required to serve as a vital center for swift, effective relief efforts in addition to their usual roles. To prevent such facilities from malfunctioning, measures to strengthen their seismic resistance should be taken. Possible roles that airport facilities are expected to play when an earthquake happens are listed below:

- Acceptance of emergency relief teams and relief goods from abroad
- Domestic transport terminal alternative to land transport
- Temporary storage of relief goods
- Treatment and transport of debris and garbage

In order for the facilities to play the roles listed above, guidelines or contingency plans should be drawn up in advance.

1) Characteristics of Airport Damage

Although there are some reports concerning damage to airport facilities in the earthquakes in the past, there are no reports that any airports were damaged too seriously to continue operations. The nature of damage observed in the past is as follows:

- Minor damage to passenger terminals
- Minor damage to control towers
- Irregular displacement of pavement between taxiways and runways
- Damage to the surface of runways and taxiways due to liquefaction

In the Loma Prieta Earthquake in 1989 in San Francisco, most of the damage was minor, and specific types of damage reported were as follows:

- At the San Francisco International Airport, power supply facilities were damaged and at the airport control tower, ceiling tiles fell and windows were broken, resulting in the cessation of the operation for approximately 13 hours. At the passenger terminals ceiling tiles and video monitors fell and some internal equipment was knocked down. Due to the breakage of sprinklers and piping, the international terminal flooded on a small scale, and the North Terminal on a relatively large scale. One of the cargo terminals was forced to be closed as it suffered from serious damage and was in danger of collapsing. Other than this terminal, recovery was made smoothly so that the operation of the airport resumed the following day.

- It was to the runway that the most serious damage occurred at the Oakland International Airport (see Photo 10-4). Of its 10,000-foot runway, a portion of 3,000 feet was made unserviceable. The apron and turnaround area had extensive cracking, but remained usable. A water main ruptured. At an old building in Terminal One, structural members supporting the concourse were damaged. At Terminal Two, built in 1985, on the other hand, damage confirmed was limited to some cracks in corridor walls.

Extracted from USGS website (http://walrus.wr.usgs.gov)

Photo 10-4 Northwest End of Main Runway (bottom) and Adjacent Taxiway (top) at Oakland International Airport

- At the San Jose International Airport, some windows in the control tower were damaged slightly, additionally, a water pipe burst, flooding a parking area, though slightly. The airport itself managed to continue its operation making use of an emergency power supply.

2) Recommendations / Measures to Make Airport Facilities Quakeproof

To secure the functions of the airport facilities on a constant basis, measures necessary to make the Algiers airport, along with its old buildings, quakeproof should be taken. Moreover, the old passenger terminal buildings should be retrofitted to improve quake resistance and secondary damage, caused by equipment, furniture and other objects falling or being displaced, should be prevented so that the evacuation process will not be affected.

According to results of the seismic motion analysis (of Khair al Din and Zemmouri) carried out in line with this study, parts of the Algiers airport are located in a high acceleration area. Hence, it is recommended that seismic diagnostic tests should be conducted on the airport facilities in order to reconfirm its safety.

Furthermore, loss of the electrical power supply will greatly affect the operation of the airport, and necessary strengthening of an emergency electric supply should also be examined.

10-4-2 Lifelines

Damage to the water and sewerage system, electricity, gas, telecommunications and other lifeline facilities has a considerable impact, not just on the management of these facilities themselves, but on various aspects of everyday life. One outstanding feature of damage to essential utilities is that the breakdown of one particular utility system or facility may lead to a chain reaction of failures of other systems or facilities.

In the event of a great earthquake, facilities that have come through unscathed will play a crucial role in rescue and relief efforts and recovery and rehabilitation activities of the region hit by the disaster.

This chapter gives an account of the impacts of damage to lifeline facilities and possible future measures to make them quakeproof.

(1) Water Supply Systems

1) Effects of Damage to Water Supply Facilities

Table 10-33 shows major effects of damages to water supply facilities.

Table 10-33 Effects of Earthquake Damage to Water Supply Facilities

Effects	Expected Problems, etc.
Network location	- Underground
Direct effects of damage to facility	- Inundation or road subsidence caused by water leakage
Effects on road transportation	- Closure of road caused by road subsidence - Damage to underground facilities and blockage caused by recovery work
Effects on daily life	- Loss of drinking water - Loss of water in rest rooms or toilets - Cooking and washing facilities disabled - Bath rooms disabled
Effects on earthquake disaster activities	- Effect on medical activities - Effect on fire fighting activities
Alternate methods	- Wells - Water tank trucks

2) Recommendations / Measures to Make Water Supply Facilities Quakeproof

In the Study Area, a total nine types of materials are used for water supply pipelines, of which the cast iron pipe is made use of the most (for lines of 977.57 km out of the total 2,148.35 km, see Table 10-34). The Study has found that, in the case of the earthquake in Khair al Din, cast iron was affected the most in terms of the number of points damaged (1,483 points among 3,965 points damaged as a whole), and asbestos cement in terms of the proportion to all lines damaged (4.32 points/km).

Table 10-34 Summary of Damage Estimation for Water Supply Pipelines

Material	Length (km)	Khair al Din		Zemmouri	
		Damage Points	Damage Ratio (points/km)	Damage Points	Damage Ratio (points/km)
Asbestos Cement	188.84	815	4.32	526	2.79
Galvanized Steel	171.47	510	2.97	310	1.81
Concrete	0.01	0	0.00	0	0.00
Precast Concrete	218.21	0	0.00	0	0.00
Cast Iron	977.57	1,483	1.52	538	0.55
Ductile Iron	278.47	25	0.09	4	0.01
Gray Cast Iron	297.96	1,119	3.76	249	0.84
Polyethylene	4.44	0	0.00	0	0.00
PVC	10.59	11	1.04	7	0.66
Unknown	0.79	2	2.53	2	2.53
Total	2,148.35	3,965	1.85	1,636	0.76

It is recommended that materials particularly vulnerable to earthquake ground motions, such as the asbestos cement, the galvanized steel, the cast iron and the gray cast iron, should be replaced, in accordance with the existing project plans to improve the water supply system, with polyethylene pipe, a material with a strong quake resistance. Where joints of the major pipelines and joints to connect vital facilities with pipelines are concerned, it seems effective to adopt flexible connections to improve the quake resistance.

(2) Sewerage Systems

1) Effects of Damage to Sewerage Systems

Table 10-35 shows major effects of damage to sewerage systems.

Table 10-35 Effects of Earthquake Damage to Sewerage Systems

Effects	Expected Problems, etc.
Network location	- Underground
Direct effects of damage to facilities	- Degradation of the hygiene environment
Effects on road transportation	- Hazard to moving traffic caused by blockage of flow of rain water - Damage to underground facilities and blockage caused by recovery work
Effects on daily life	- Toilets Disabled - Cooking and washing inhibited - Bath rooms disabled
Effects on earthquake disaster activities	- Degradation of public sanitation condition
Alternate Method	- Temporary toilets

2) Recommendations / Measures to Make Sewerage Systems Quakeproof

In the Study Area, old masonry sewerage pipelines laid down during the colonial period are still in use. It is uncertain whether or not they are in good shape, but it is highly likely that their quake resistance is less strong than that initially designed because of aging. It is thus necessary to replace them with new pipes in case of earthquakes, and manage them on a usual basis.

In the meantime, the main parts of the sewerage network have been digitalized and a GIS system has been adopted in line with this survey, while branch pipelines of the network have not been included in the GIS. Thus, it is recommended that the sewerage pipeline network as a whole should be surveyed so as to create a comprehensive database for drawing up a quakeproof plan.

(3) Electric Power Supply Systems

1) Effects of Damage to Electric Power Supply Systems

Table 10-36 shows major effects of damage to electric power supply facilities.

Table 10-36 Effects of Earthquake Damage to Electric Power Supply Systems

Effects	Expected Problems, etc.
Network location	- Aerial / Underground
Direct effects of damage to facilities	- Danger from short circuiting and collapsing of utility poles - Fire after resuming power distribution
Effects on road transportation	- Hazard to moving traffic caused by malfunction of traffic lights - Lack of lighting at night - Damage to underground facilities and blockage caused by recovery work
Effects on daily life	- Electric power failure - TVs, refrigerators, etc disabled - Elevators disabled - Panic caused by electric power failure - Effect on medical activities
Effects on earthquake disaster activities	- Computers disabled - Facilities operated by electricity disabled - Electric equipment such as TVs, videos, etc. disabled - Communication tools disabled
Alternate methods	- Emergency generators - Private power generators - Emergency power source cars - Switching channels of distribution - Electric torches, candles

2) Recommendations / Measures to Make Electric Power Supply Systems Quakeproof

Where the electric power supply of medium voltage in the area surveyed is concerned, aerial cables with poles are made use of in rural areas and underground cables in urban areas. A survey of damage to medium-voltage electric power supply facilities in the case of Khair al Din estimates that 199 m (out of 123,797 m in total length) of the aerial cables and 1,465 m (out of 671,326 m in total length) of the underground cables were apparently damaged. The proportion of cables damaged - both types of cables - as a whole is approximately 0.2%. It is said in general that underground cables are less vulnerable to earthquake or other kinds of disasters than aerial cables in that the former are coated with protective materials. Nevertheless, a majority of the underground cables in the region surveyed are directly buried, so that they are very prone to any ground deformation: possible damage to the underground cables may be as much as that to aerial cables. In the meantime, utility poles which will be brought down when a great earthquake occurs are highly likely to block roads.

Hence, in order to minimize damage to electric power cables, the existing medium-voltage cables should be moved to the multipurpose underground conduits which have been rarely damaged by natural disasters, though it is necessary, at the same time, to take into account the economic efficiency of this measure.

(4) Gas Supply

1) Effect of Damage to Gas Supply Facilities

Table 10-37 shows major effects caused by damage to gas supply facilities.

Table 10-37 Effects of Earthquake Damage to Gas Supply Facilities

Effects	Expected Problems, etc.
Network location	- Underground
Direct effects of damage on facility	- Possibility to set off a gas explosion due to collapse of a storage tank / pipeline
Effects on road transportation	- Hazard to moving traffic caused by the explosion - Damage to underground facilities and blockage caused by recovery work
Effects on daily life	- Cooking facilities disabled - Heating appliances (especially important in winter) disabled
Effects on earthquake disaster activities	- Inefficient preparation of meals outdoors
Alternate method	- Propane gas

2) Recommendations / Measures to Make Gas Supply Systems Quakeproof

There are 3 types of pipe materials (steel, polyethylene and copper) for medium pressure gas pipelines used in the Study Area. The copper pipes were laid down in the early period of the infrastructure development and are used also for the supply of the low pressure gas. This fact suggests that the copper pipes will be damaged fairly seriously if a great earthquake occurs (3.06 points/km in the case of the earthquake in Khair al Din). On the other hand, it is expected that the damage to steel and polyethylene pipes will not be so grave.

Currently, SONELGAZ is going ahead with a project to replace the copper pipes with polyethylene pipes. From the viewpoint of seismic strengthening of the infrastructure, it is hoped that this replacement project will be completed without any difficulties.

Risers, the pipes that connect the underground pipes to the individual premises of the consumers, are one of the most crucial facilities in a gas supply system, in that they could be damaged as seriously as the premises when hit by a severe disaster. Once a building has fallen and the related risers damaged, the gas leakage, which is apt to occur due to the current, insufficient preventive measures, is highly likely to cause a secondary disaster. In this regard, it is necessary to consider launching measures to make gas-related risers quakeproof - that is, for example, creation of a system to halt gas supply automatically when a great earthquake occurs - together with measures to reinforce quake resistance of buildings.

(5) Telecommunications

1) Effect of Damage to Telecommunications

Table 10-38 shows major effects of damage to telecommunication facilities.

Table 10-38 Effects of Earthquake Damage to Telecommunications

Effects	Expected Problems, etc.
Network location	- Aerial / Underground
Direct effects of damage to facilities	- Danger from collapsing of utility poles
Effects on road transportation	- Damage to underground facilities and blockage caused by recovery work
Effects on daily life	- Telephones disabled
Effects on earthquake disaster activities	- Information sharing reduced - Facsimile machines disabled
Alternate methods	- Community wireless radios - Satellite telephones - Walkie talkies

2) Recommendations / Measures to Make telecommunications Quakeproof

In this Study, no estimation was made concerning possible damage to telecommunications. Even so, it is certainly effective to make use of multipurpose underground conduits for telecommunications, as in the case of the electric supply cables described above.

The number of subscribers of mobile telephones has been sharply increasing in recent years, so that mobile telephones have been considered to be useful devices as telecommunication means (although it is still necessary to deal with congestion control when a great earthquake occurs). Therefore, it is important to minimize damage to mobile phone antennas for the purpose of securing communication networks even after such a disastrous event has happened.

Chapter 11. Database for Urban Disaster Management

11-1 Database for Urban Disaster Management

(1) Outline of the Database for Urban Disaster Management

The JICA Study Team prepared an urban disaster management database using a GIS for the micro-zoning area that consists of 34 communes. This work was done as one of the disaster preparedness measures for earthquake hazards.

ArcGIS (ArcView 9) for the Windows operating system was used as the standard GIS software for developing the urban disaster management database and the geographic data. The ESRI Shapefile format was used as the standard file format for vector GIS data in the urban disaster management database.

In addition to the basic GIS datasets mentioned in Chapter 2, the surveyed existing disaster management resources within the 34 communes were digitized and arranged as a separate GIS dataset. Table 11-1 shows the features that were targeted as disaster management resources in this additional dataset. Both the basic GIS datasets and the disaster management resource dataset form the urban disaster management database.

Table 11-1 Disaster Management Resources

Resources	Vector type	Targeted features
Parks	Polygon	Public Parks (all parks)
Vacant Land	Polygon	Vacant land (1 ha and over in area)
Sporting Fields	Polygon	Open-air sports fields (athletics fields,, tennis courts, etc.)
Airports	Polygon	Airfields
Ports	Polygon	Ports
Water	Polygon	Inland water (water bodies; as a possible water source)
Police	Polygon	Police stations
Military	Polygon	Military buildings, and related buildings/facilities
Civil Protection	Polygon	Civil Protection Stations
Educational	Polygon	Educational sites: schools, colleges, universities
Administrative	Polygon	Governmental/administrative sites, including buildings/facilities
Public	Polygon	City auditoriums, public halls
Indoor Sports	Polygon	Gymnasiums (excluding those of schools, colleges, universities)
Medical/Health	Polygon	Hospitals, clinics, health centers
Religious	Polygon	Mosques, churches, temples
Sanitation	Polygon	Sanitation sites
Disposal/Garbage	Polygon	Waste disposal treatment sites

Data Source: JICA Study Team

By manipulating the datasets described above, relevant thematic maps that are useful to people in charge of urban disaster management were generated. The input data were obtained from the micro-zoning study and the urban vulnerability assessment that are described in earlier chapters of this report.

(2) Map and Data Operation System

As mentioned above, all kinds of digital data (files) can be manipulated with ArcGIS 9. However, it is time-consuming to master the functions of ArcGIS 9 for inexperienced GIS operators or experts not familiar with the ArcGIS 9 software. The difficulty of ArcGIS 9 for the Algerian counterparts might lead to problems in information exchange and sharing in relation to the urban disaster management work.

In order to assist the Algerian counterparts to utilize the urban disaster management database developed by the JICA Study Team, the following modules were created:

1) HTML-based Module

This module presents a user-interface (map and data catalog) that allows all levels of database users to query the thematic maps easily. With this module, the users can carry out the following manipulations of the urban disaster management database:

- Query a thematic map and the relevant GIS datasets that form the targeted thematic map, and
- Download targeted maps via modules (the catalog). Each thematic map is stored in a particular data format. The user can select one or more data formats and create a thematic map for their own purpose.

This module is easily customizable by the Algerian counterparts, and the datasets within this module can easily be shared with stakeholders by storing on the Internet or by distributing CDs or DVDs. This module gives users a smooth interface for accessing the various datasets.

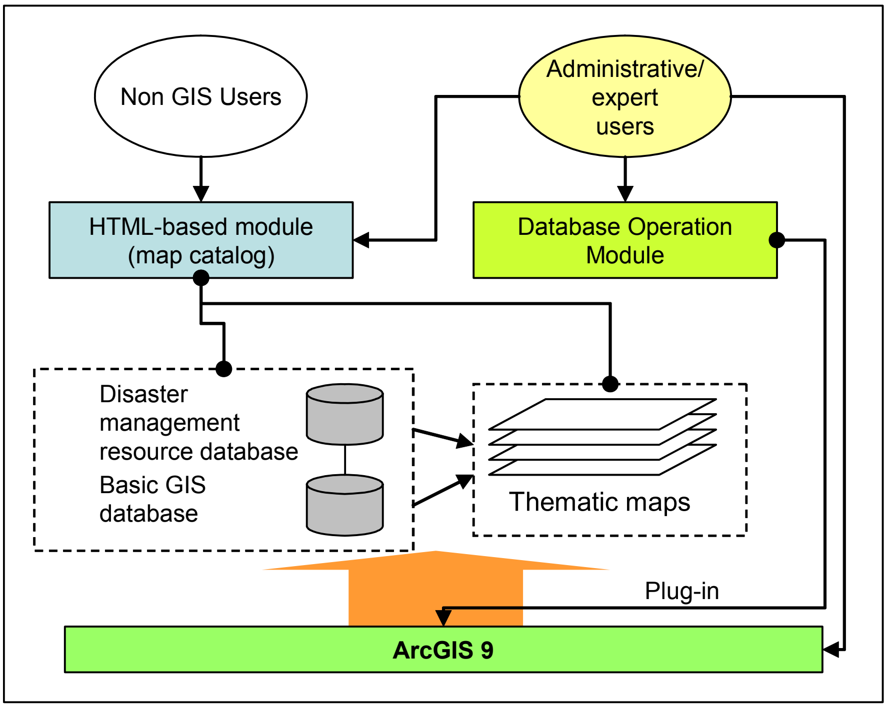
2) Database Manipulation Module

This module targets administrative/expert level users. The module provides a user-oriented interface (dialog modules) and it was developed for ArcGIS 9 users who need to update or edit the datasets in the urban disaster management database.

(3) Urban Disaster Management Information System

Figure 11-1 below shows a conceptual diagram for the urban disaster management information system, including the databases and the user modules.

Technical details of the system and database are described in the following sections (Section 11-2 and Section 11-3).



Source: JICA Study Team

Figure 11-1 Conceptual Diagram for the Urban Disaster Management Database

11-2 Development of User Interface System

11-2-1 Objectives

The useful lifespan of the constructed database depends on the accessibility and usability of the software and data itself. Especially, updating the constructed information is a key issue for it.

Although ESRI ArcGIS (ArcView) is very powerful user friendly GIS software, it does not give user friendly interfaces for inputting attribute information to users. It requires significant experience and the knowledge of the database for proper updating.

For this reason, input supporting systems, customized interfaces, have been created to help improve the usability of handling attribute information. In addition to this, a Buffering button has been created for higher operability to create and analyze resources for disaster prevention.

11-2-2 Data Entry Support System

A Data Entry Support System has been created as a VBA (Visual Basic for Application) code for acquiring compatibility with the ESRI ArcGIS. Thus, any User can change, update or refine the created system with some knowledge of Visual Basic and ArcGISs' ArcObjects architecture.

User event; clicking the "Protection Resource" toolbar will call the main module of this system stored in the ArcGIS project file "MXD" as if only one feature on the display was selected, otherwise the system will be aborted.

Within the main module, the layer in which the selected feature belongs will be detected and the proper user form will be loaded into the memory of the computer. As the form is loaded, the form calls the attribute information of the selected feature and fills the necessary information on the controls itself. The form also calculates administrative boundary information in which the selected feature sits and adds sequential ID to the newly created polygon with acquired information from the administrative boundary.

As user input attribute information on the controls of the form, data type and threshold of the inserted information will be checked. If an improper attribute is inserted, an error message appears and the inserted information is aborted.

Also a buffer button is attached to the toolbar and it gives the user a means to create an arbitrary distance buffer to a selected feature to help supply better functionality to the Vulnerability analysis. The buffer button is triggered by an under click on the display field of ArcMap, and the event calls the system function with an Input Box. As the user inputs a given distance and clicks the "OK" button, a buffer will be created as a graphic feature of ArcMap.

Basically, the system utilizes ArcObjects, libraries which ESRI supplies as modules of the GIS functions of the ArcGIS. Thus, the same functions can be performed from the non-customized interface of ArcGIS, although that requires more steps and knowledge of the tools of ArcGIS.

The conceptual flow of the system procedure is described as follows:

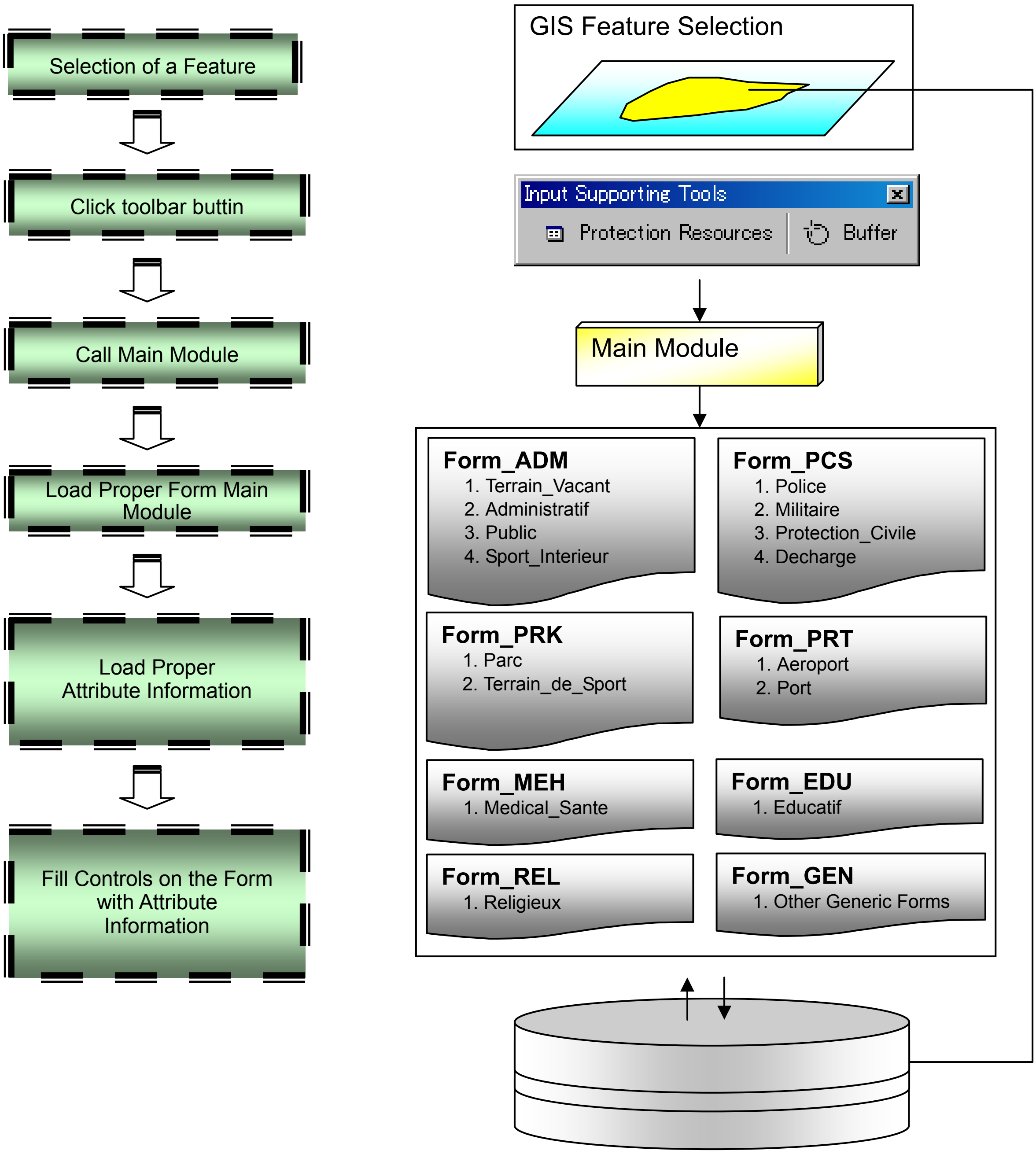


Figure 11-2 Conceptual Flow of Data Entry Supporting System

To perform this, functions have been constructed as VBA codes within the ArcGIS project file, MXD. As the user inputs a defined event to the ArcMap, those functions are called as intended.

The basic function and steps of the system are depicted in the following diagram, Figure 11-3.

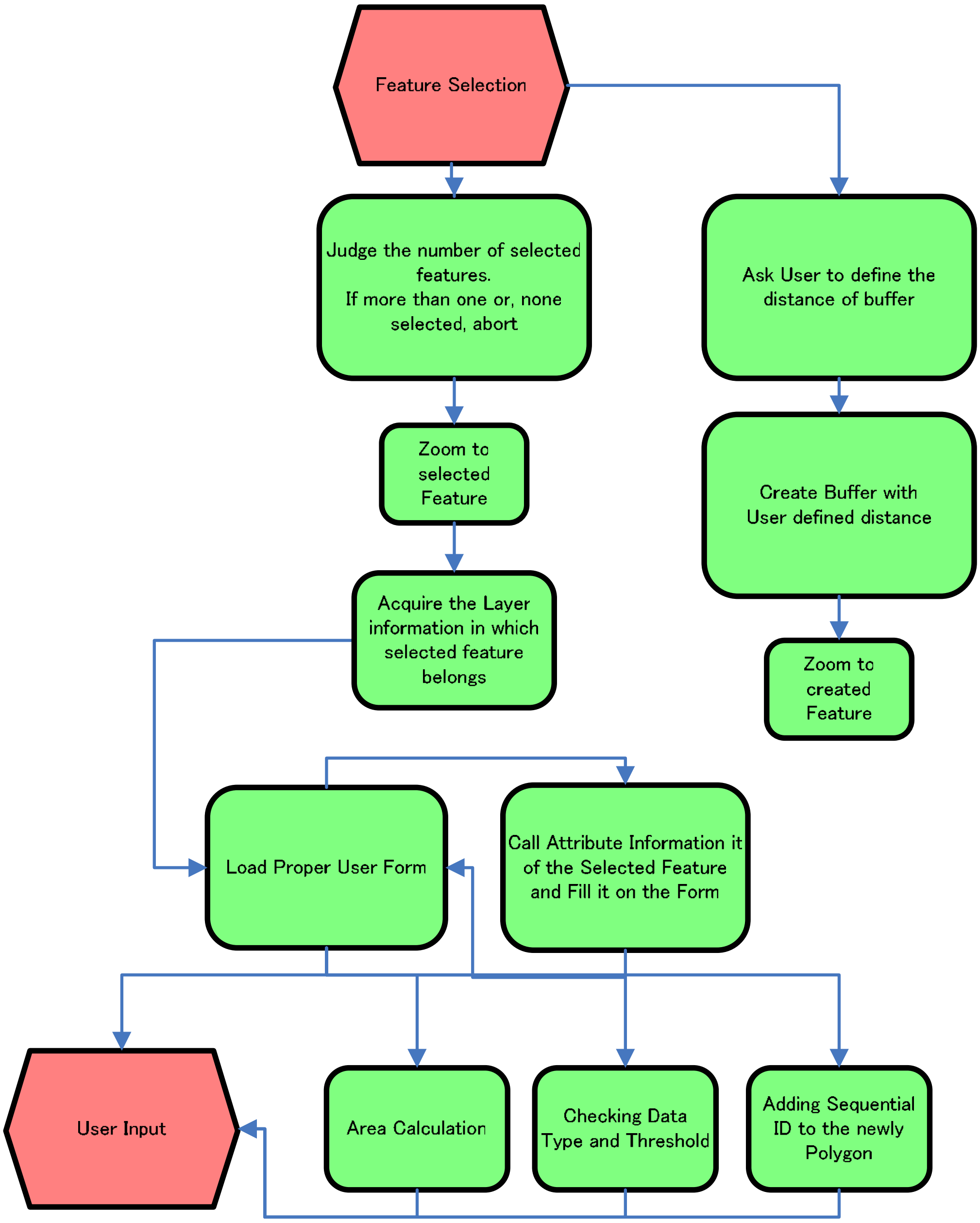


Figure 11-3　Basic Functions and Flow of the Data Entry Support System

11-2-3　HTML-Based Module : Map Browsing System

All results will be delivered through a media like CD or DVD to related users, some are GIS users and the others are Non-GIS users.　Hence, the contents of the media should be able to be accessed as both GIS database and Non-GIS output.

Non-GIS users can access the contents through the Data Browser, which was created as HTML and linked to various outputs.　Click the hyper link bar to activate the data-viewer with the linked datasets.　Non-GIS users can see the output through a data-viewer.　The detailed dataset and output is described in the data book attached.

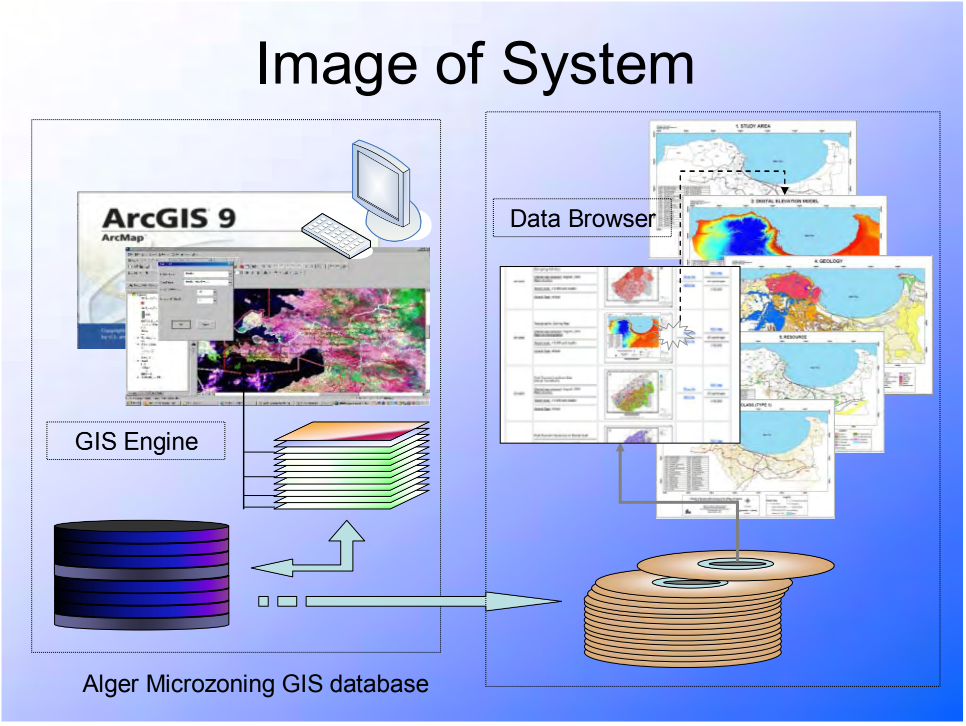


Figure 11-4 Image of Data Entry Support System and Map Browsing System

11-2-4 GIS Data Viewer; ArcExplorer

As a supplement for the system, ArcExplorer projects files for viewing the GIS database directory for users who do not have ArcGIS.

ArcExplorer is a lightweight GIS data viewer. It is free software supplied by ESRI, vender of ArcGIS, and can perform basic GIS functions, displaying, querying and data retrieval.

Thus, the user can perform simple GIS operations through this software after installing this on their own environment.

11-3 Operation and Maintenance Plan

Regarding the purpose of this project, sharing the output of the analysis is essential. Thus two modules have been developed, one is for manipulating the contents of the database, and the other is for sharing the output of this project as mentioned in Section 11-1.

Concerning the circulation of the information, the two following entities will be the recipients.

1. Non GIS-Users
2. Administrative and expert GIS users

Non GIS users are the ones who have acquired information through ready made output which was created and prepared by the Administrative groups.

The Administrative group's duty is constructing, updating, refining and performing the feed back of those results to the Non-GIS users

Algerian counterparts have established cross an organizational entity which consists of **CGS**, **URBANIS** and **DGPC** for acquiring synergetic effects to help develop the skills related to GIS matters. This entity is going to become the expert Administrative GIS user which constructs, updates and refines the GIS database for disaster prevention.

For Operation and Maintenance, the following activities are essential and are included in the roles of this entity.

1) Construct GIS database for other projects
2) Update and Refine the existing GIS database
3) Feed back the result of the update and refining output as HTML

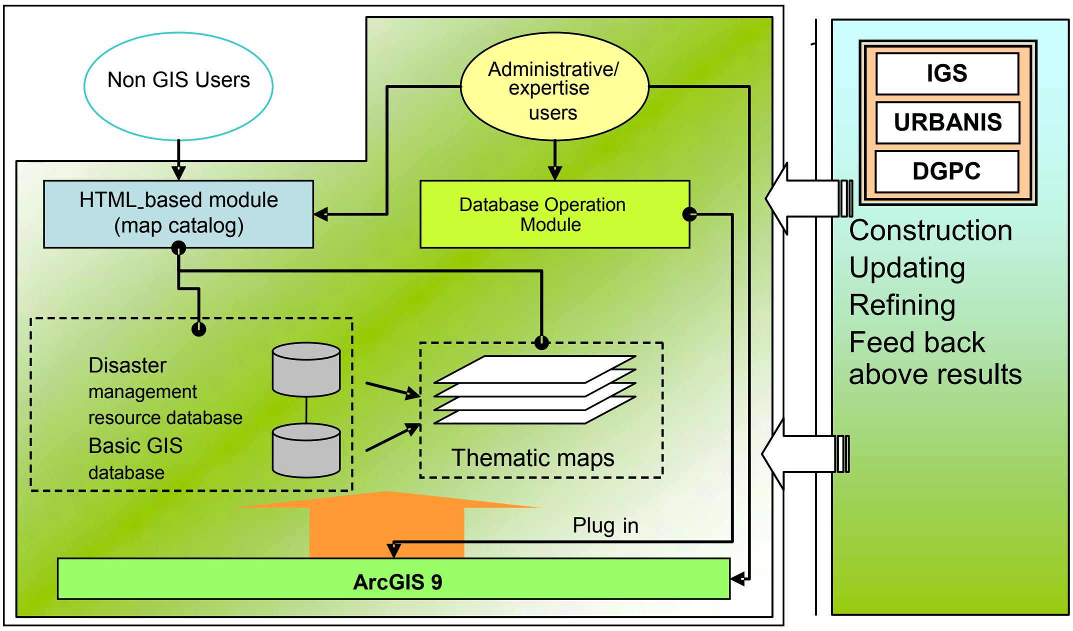


Figure 11-5 Conceptual Flow of Operation and Maintenance

Activity 1) and 2) will be performed through the Interfaces of the ArcMap (ArcView Version) and Add on (supplied system). Activity 3) will be performed by replacing the contents of the output of the HTML based system and redeliver medias like CD or DVD to Non-GIS users. The duration of redelivering is based on the degree of the change of the contents.

CHAPTER 12

TECHNOLOGY TRANSFER OF SEISMIC MICROZONING

Chapter 12. Technology Transfer of Seismic Microzoning

12-1 Scenario Earthquakes

(1) Contents and Schedule

The overall schedule, counterpart personnel and transfer items are summarized in Table 12-1.

Table 12-1 Schedule and Contents of Technology Transfer for Scenario Earthquakes

Contents	Counterpart	Study Team	Date/Time
Discussion on the CGS review report of the JICA interim report	Y. Bouhadad	Mouroux, Bertrand	14/05/06 Morning
Discussion on CGS review report of the JICA interim report and technology transfer	Y. Bouhadad	Bertrand	14/05/06 Afternoon
Work meeting for technology transfer (use of Excel spreadsheets, input of data, formulas and graphics).	Y. Bouhadad	Bertrand	15/05/06 Afternoon
Work meeting for technology transfer (Equations for calculation of magnitudes versus return period, attenuation laws, etc.)	Y. Bouhadad	Bertrand	16/05/06 Morning

(2) Discussion on the CGS review report of the JICA interim report

In the discussion on the CGS review report of the JICA interim report, MM. Mouroux and Bertrand showed M. Bouhadad:

1) that seismotectonic models used by i) JICA and ii) BURGEAP are similar and consistent for most seismic sources.

2) that the differences in the JICA seismotectonic model compared to the BURGEAP model do not result from over-interpretation as they rely on published data

3) that the methodologies used by i) JICA and ii) BURGEAP are very different (earthquake scenario and global hazard mapping respectively), therefore the results could hardly be compared.

CGS and JICA still disagree on the following points: (i) that the proposed seismotectonic model used by JICA is generally consistent with the BURGEAP one, in terms of traces of active faults but is very different in terms of the seismic potential of active faults which result from expert judgment. (ii) That the proposed seismotectonic model which considers a Mega-thrust fault offshore represented by the Khair al Din fault is not justified by data and hence we consider that it constitutes an over-interpretation.

M. Bertrand carefully presents and explains methodology for seismic hazard assessment, i.e.:

1) elaboration of the seismotectonic model
2) calculation of magnitudes (MCE and magnitude vs. return period curves)
3) calculation of source-to-site distances
4) calculation of ground motions (PGA)

(3) Results

Comments addressed in the CGS review report on the Interim report were thoroughly discussed. These comments concerned mostly two points, the seismotectonic model and the methodology, stressing the differences with a study presently conducted by BURGEAP:

1) The seismotectonic models are consistent between the 2 studies (BURGEAP and JICA); in terms of traces of active faults except for the trace of the Chenoua fault. But these studies are not consistent in terms of seismic potential of active faults, velocity of the Sahel and other faults for which divergence remains.

2) The two approaches followed by JICA and the BURGEAP are very different, (earthquake scenario for JICA, global hazard mapping for BURGEAP) but also the attributed geometrical and seismotectonic parameters are different and the results obtained in the two studies could hardly be compared.

M. Bouhadad suggested that the Oued Fodda fault (source of the El-Asnam 1980, Ms = 7.3 earthquake, is the most documented active fault in Africa (several paleoseismic studies have been performed i.e. WCC, 1984; Swan, 1988; Meghraoui et al 1988a; Meghraoui et al., 1988b; Meghraoui et Doumaz, 1996 and it presents strong geomorphic and structural analogies with the Sahel fault) and that the high slip rate (as high as 2.5 mm/yr) should be considered on the Sahel fault. His argument is that this slip rate has been proposed for the Oued Fodda fault (source of the El Asnam earthquakes).

We disagree on such a high velocity on the Sahel fault for the following reasons:

1) A high velocity (in the order of a few mm/yr) has been calculated for the Oued Fodda fault from paleoseismic studies. Long term velocity is more representative of slip rates as they include a large enough number of earthquakes to be statistically relevant (Figure 12-1). Long term velocity of the Oued Fodda fault is much lower (a few tenths of a mm/yr) than the short term.

2) Slip rates of the Oued Fodda fault cannot be extrapolated to the Sahel fault, putting aside the velocity constraints that are available there (marine terraces).

3) Absolute elevation of marine terraces on the back limb of the Sahel anticline give a velocity of 0.2 mm/yr that we believe could be as high as approx. 0.4 mm/yr (Figure 12-2).

4) A fast slip rate of the Sahel fault would result in a northward tilting of the marine terraces (this is the case in Tipaza harbor) on its back while these terraces are actually slightly tilted southward evidencing an active and faster fault offshore.

5) As the sense of tilt of marine terraces is an indicator of relative velocity, this offshore fault (Khair al Din) should have a slip rate at least as high as the Sahel fault. Similarly, the Blida fault, according to geomorphologic evidence (high topography, steep relief, well developed alluvial fans …) should also have a higher slip rate. This would lead to a much higher value than the fastest estimate of the Africa-Eurasia convergence rate!

6) High slip rate faults thrusting the Mitidja basin to the north and south would lead to its subsidence and sea incursion. This is not observed.

Finally, we point out that we totally agree with the long term slip rate (only long term slip rate should be considered here as there is no way, with the present state of knowledge, to infer whether the Sahel fault could be in a fast or quiet period) proposed by BURGEAP of 0.2 mm/yr (actually 0.1 mm/yr with weight of 0.2, 0.2 mm/yr with weight of 0.6 and 0.3 mm/yr with weight of 0.2). We have chosen, in our seismotectonic model, to increase this slip rate to 0.5 mm/yr in order, with regards to the remaining uncertainties, to be on the "reasonably conservative" side.

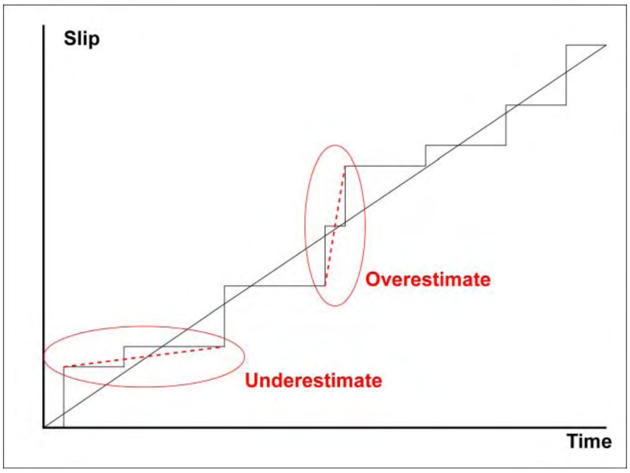


Figure 12-1 Examples of Overestimate and Underestimate of Long-term Slip-rate (straight line) when extrapolated from a limited number of seismic events (stepped line).

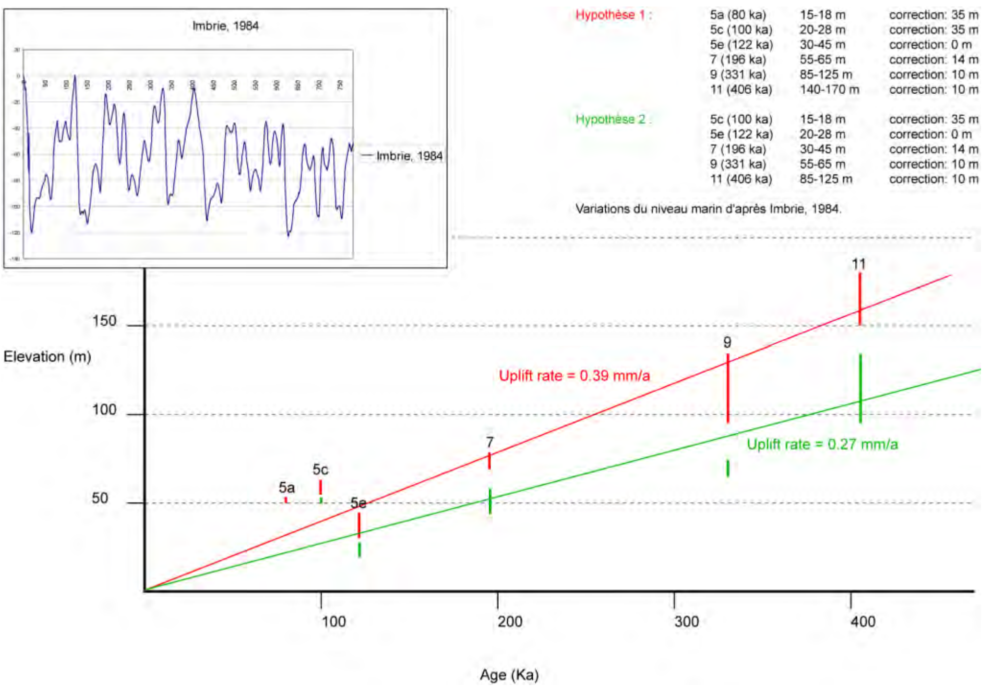


Figure 12-2 Preliminary Estimates of Slip rate from Elevation of Marine Terraces Corrected for Sea Level Variations. Two hypotheses have been considered for age of terraces.

(4) Recommendations and Conclusions

The results of this third work period in Algiers concern the following two points:

1) We believe that Mr. Bouhadad understood our answers to the comments made by CGS to the JICA interim report (for the regional seismic hazard part).

2) Mr. Bouhadad was given all necessary tools (Excel spreadsheets and copies of articles) and explanations to conduct seismic hazard calculations himself based on the seismotectonic model that was previously built by the JICA and CGS teams.

12-2 Ground Modeling and Natural Hazards

(written by N. Mezouer; Geotechnical C/P)

(1) Contents and Schedule

The transfer of technology in its geological and geotechnical analysis portion was done along with the progress of the study. It was accentuated during the period of June-July 2006 following the schedule of the table below:

Table 12-2 Schedule and Contents of Technology Transfer for Ground Modeling and Natural Hazards

Contents	Counterpart	Study Team	Date
General	N. Mezouer	Segawa	21/05/06
Soil model and response analysis	N. Mezouer	Segawa	23/05/06
Liquefaction	N. Mezouer, L. Haderbache	Segawa	24/05/06
Stability of slopes	N. Mezouer, L. Haderbache, N. Guessoum, D. Ait Benameur, M. Ait Ameur	Segawa, Nishii	29/05/06
Inspection of slopes	N. Mezouer, L. Haderbache, N. Guessoum, D. Ait Benameur, M. Ait Ameur	Segawa, Nishii	3-8/06/06

Meetings were held, questions were posed and answers given.

The transfer was mainly done for the following:

(1) Choice of attenuation formula
(2) Procedure for geotechnical investigation
(3) Geotechnical data processing
(4) Definition of bedrock
(5) Definition of models of geological columns
(6) Definition of bedrock motion
(7) Utilization of records of HUSSEIN DEY and KOUBA
(8) Choice of nonlinear properties of soils
(9) Selection of geological columns to be used in the liquefaction potential study
(10) Methods used for slope stability study
(11) Analysis of results of slope stability study
(12) Inspection of the slopes with a high landslide potential

(2) Results

1) Choice of Attenuation Formula

All necessary explanations for the choice of attenuation laws were given. The choice made within the framework of this study was conditioned by the formula integrating the nature of the bedrock, i.e. whether it is firm or loose.

2) Procedure for the Geotechnical Investigation

Very interesting discussions about the choice of mesh and the quality of geotechnical tests to be conducted were made. We understood that the mesh depends mainly upon the existing geotechnical data processing, their reliability and also upon the geology of the surveyed area without forgetting the cost of geotechnical test to be conducted. Whatever the case may be, the following must generally be targeted:

- The lithology, with its characterization in terms of thickness, bulk density, velocity of propagation of seismic shear waves for possible amplification survey, cohesion, angle of internal friction for slope stability survey, granulometry, Atterberg limits for liquefaction survey, etc.
- The depth of bedrock or of the layers presenting a contrast of high impedance to define the loose layers likely to amplify the seismic movements.

The choice of mesh depends on these data and their ranges. There must be an adequately representative distribution of all the surveyed area.

3) Geotechnical Data Processing

A very particular attention should be given to the data gathered from the literature or obtained experimentally. The reliability of data must be verified and integrated. Following the geology, loose layers over the bedrock of the studied region are identified and coded using a usual legend. For each type of layer, the averages of all the information related with this are made for a better representation. The details of this operation have been transferred to us.

4) Definition of Bedrock

The bedrock is defined from the data of the drilling made or existent data. The definition of substratum is an important step in the series of works. In general, it is defined as the layer representing the very high velocity of propagation of seismic shear waves. In certain parts of the surveyed area this bedrock was not reached by drilling (too deep). It is easy enough to determine the contour of the bedrock when the metamorphic rocks containing Miocene layers are reached. But this is not the case for the most part of the surveyed area where the hardest layers reached are marls. In this case, a decision for the choice of bedrock has to be taken; intense discussions on this subject were made. We understood that Plaisancian blue marls must be assumed as the substratum. For each type of bedrock, a velocity of propagation of seismic shear waves was retained, of course, from the average values.

5) Definition of Models of Geological Columns

From the geologic map, existing boring data, reconnaissance surveys carried out and laboratory tests, a compilation was done in a GIS. The results give the contours of the substratum as well as the model of the geological column with all geotechnical and dynamic information allowing us to subsequently study the amplification of seismic movement, the potential for liquefaction and the slope stability.

Compilation of data, i.e. generalization of spot data (drillings) in all the surveyed areas, remains to be mastered. Meetings were held during the first week of July and a demonstration was implemented.

6) Definition of Bedrock Motion

Six faults were considered in this study. The study of probability gives the level of acceleration that may be generated by each fault for a certain return period. Knowing the distance from the center of each mesh to the projection of the fault plane and considering the nature of the bedrock (solid rock, firm or loose), a law of attenuation is used to determine the acceleration at the bedrock of each mesh. Applications were made.

7) Utilization of Records of HUSSEIN DEY and KOUBA

In order to study the amplification of soils, seismic records are necessary. Interesting discussions were made about the choice of records. In conclusion, the recording has to be chosen according to the frequency content, the place of recording (close to or far from the site to be surveyed) the nature of the geological column under the recording station (bedrock or previously identified column) and, especially, a record of a seismic event in the surveyed area. These explanations justify the use of the HUSSEIN DEY and KOUBA recordings. Another choice of recording would have changed the values of the results, especially in terms of amplification.

8) Choice of Nonlinear Properties of Soils

For large seismic motion, loose soil layers exhibit a nonlinear behavior proportional to the level of the strain produced. These strains reduce the rigidity of soils and increase damping. Models of nonlinear behaviors are to be used with a great care. Discussions were held about the choice of models.

9) Selection of Geological Columns to be used in the Liquefaction Potential Study

In order to optimize the analysis, geological columns previously classified as being constituted of sand layers saturated to some extent were selected. Considering the data of these columns (N_{SPT}, D50, FC, Ip), the Japanese method (Japan Road Association) was used for estimation of the liquefaction potential at each depth. The effect of this potential at each mesh was subsequently evaluated by the P_L method. This index tells us the importance of the effect of liquefaction (high, relatively high, etc.). Discussions were held and demonstrations given.

10) Methods Used for the Slope Stability Study

Two types of sloped grounds are to be distinguished: steep or moderate. In general, the geology of the ground is used for this distinction. Rocky soils on slopes are classified as steep slopes and their instability causes a collapse. The rest of the soils are classified as moderate slope and their instability causes a landslide.

For each type of slope, an evaluation method of the potential stability was chosen. The methods were discussed in detail. It is to be noted that it is necessary to have the proper data to carry out this survey. These are the geotechnical data (angle of internal friction, cohesion) and a numerical ground model (DEM) giving all the slopes of the site to be studied.

11) Analysis of Results of the Slope Stability Analysis

The results of this study are in the form of coefficients indicating the landslide potential of the slopes (high, moderated, low) for each mesh of the DEM. A conclusion is necessary to choose the mesh scale of the initial study (250 m x 250 m). For this, a static analysis was made to draw the conclusions relative to the size of the study mesh.

12) Inspection of the Slopes with a High Landslide Potential

From the results of the analysis of the landslide potential, all the meshes or sectors presenting a high potential are subject to field inspection and verification. This inspection begins with marking of these sectors on a map. Inspection forms used in Japan are to be filled in. These forms take account of several parameters such as density of habitation, slope height, existence of water and of roads. Compilation of all of this field information leads us to the final result as to the landslide potential. The forms have been explained, the field survey has been implemented and the analysis of the inspection forms has been conducted.

(3) Conclusions

All the responses to the questions posed following a handing-over of the interim report have been given. The meetings for transfer of technology were beneficial as well as were the different weekly meetings.

Certain details related to the use of the geographic information system (GIS) remain for this part (geotechnical probabilities), but this is a continuing group work where each one has to contribute his knowledge.

12-3 Damage Estimation

12-3-1 Buildings

(1) Contents and Schedule

Items on which the technology transfer was conducted are as follows:

a) Methodology of a damage function utilizing the structural seismic index, Is,
b) Methodology for a distribution of structural seismic indexes, Is.

Overall schedule, counterpart personnel and transfer items are summarized in Table 12-3.

Table 12-3 Schedule and Contents of Technology Transfer for Damage Function of Buildings

Contents	Counterpart	Study Team	Date
Approach to Damage Function	Y. Mehani, A. Remas	Kagawa	16/05/06
Data collection and how to use data of the 2003 Boumerdes earthquake	Y. Mehani, A. Remas	Kagawa	17/05/06
Basic solution with flow chart of Damage Function	Y. Mehani, A. Remas	Kagawa	20/05/06
2nd and 3rd level screening procedure of the structural seismic index, Is	Y. Mehani, A. Remas	Kagawa	21/05/06
Damage function and data collection	Y. Mehani, A. Remas	Inoue	29/05/06
Distribution of structural seismic indexes, Is, and damage curve	Y. Mehani, A. Remas	Inoue	30/05/06
Evaluation and calculation of damage curve for RC frames	Y. Mehani, A. Remas	Inoue	31/05/06
Evaluation and calculation of damage curve for RC frames	Y. Mehani, A. Remas	Inoue	03/06/06
Evaluation and calculation of damage curve for Steel and Masonry structures	Y. Mehani, A. Remas	Inoue	04/05/06
Evaluation and calculation of damage curve for old Brick Masonry	Y. Mehani, A. Remas	Inoue	05/06/06
Evaluation and calculation of damage curve for RC frames built to RPA99 and 2003	Y. Mehani, A. Remas	Inoue	06/06/06
Evaluation of methodology of damage function from damage data	Y. Mehani, A. Remas	Inoue	19/06/06

(2) Results

Comments addressed in the CGS review report on the JICA interim report were thoroughly discussed. These comments concerned mostly two points;

a) Methodology of a damage function utilizing the seismic index of an RC structure, Is, and for various types of structures with assumptions. The damage function for steel and masonry structures was supposed to be estimated from an analogy of RC frames.

b) Determination of a distribution of structural seismic indexes, Is.

(3) Recommendations and Conclusions

The results of this third work period in Algiers concern the following two points:

a) We believe that Mr. Mehani and Mr. Remas understood our answers to the comments made by CGS to the JICA Interim Report (Methodology of damage function analysis for building structures) and agreed with them; they made no further comments after we presented our answers and explanations to their initial comments.

b) Mr. Mehani and Mr. Remas were given all the necessary explanations so that they could independently conduct damage function analyses for various type of building structures with assumptions.

12-3-2 Infrastructure and Lifelines

(1) Item and Schedule

The overall schedule, the counterpart personnel, Mr. Abderrahmane KIBBOUA (hereinafter referred to as "the counterpart"), and transfer items are summarized in Table 12-4.

Table 12-4 Schedule and Contents of Technology Transfer for Infrastructure and Lifeline

Contents	Counterpart	Study Team	Date
Explanation of Interim Report	A. Kibboua	Miyazaki	13/05/06
Data collection and verification	A. Kibboua	Miyazaki	14-17/05/06
Damage estimation for bridges	A. Kibboua	Miyazaki	20/05/06
Damage estimation for the port	A. Kibboua	Miyazaki	21/05/06
Damage estimation for airport	A. Kibboua	Miyazaki	22/05/06
Verification of the damage estimation method for bridges, the port and airport (1)	A. Kibboua	Miyazaki	23/05/06
Verification of the damage estimation method for bridges, the port and airports (2)	A. Kibboua	Miyazaki	24/05/06
Damage estimation for lifelines	A. Kibboua	Miyazaki	27/05/06
Damage estimation for the water supply and sewerage pipelines	A. Kibboua	Miyazaki	28/05/06
Damage estimation for medium voltage aerial cables	A. Kibboua	Miyazaki	29/05/06
Damage estimation for medium voltage underground cables	A. Kibboua	Miyazaki	30/05/06
Damage estimation for medium pressure gas pipelines	A. Kibboua	Miyazaki	31/05/06
Calculation of damage estimation	A. Kibboua	Miyazaki	03-07/06/06
Review of the entire method and result of the damage estimations	A. Kibboua	Miyazaki	09/06/06

(2) Results

1) Explanation of Interim Report

An expert on infrastructure in the JICA Study Team explained the related contents of the Interim Report to the counterpart, and exchanged opinions about the schedule of this phase etc.

2) Data collection and verification

The counterpart and the expert visited the related organizations / enterprises in order to collect the required data and verify the data compiled by the JST for the damage estimation.

3) Damage estimation for bridges

The expert explained Katayama's Method to the counterpart.

4) Damage estimation for the port

The expert explained to the counterpart that the port damage estimation was examined considering the relationship between PGA and damage conditions based on past earthquake records.

5) Damage estimation for the airport

The expert explained to the counterpart that the airport damage estimation was also examined considering the relationship between PGA and damage conditions based on past earthquake records.

6) Verification of the damage estimation method for bridges, the port and airport 1/2

The counterpart conducted the verification for the bridges, the port and the airport using the Boumerdes Earthquake records (El Harrach Bridge and Sebau Bridge, Algiers port and Algiers airport).

7) Verification of the damage estimation method for bridges, the port and airport 2/2

The counterpart and the expert discussed the result of the verification, and confirmed with each other that their methodology is suitable for this project.

8) Damage estimation for the lifelines

The expert explained the concept of the damage estimation for the lifelines to the counterpart. At this time, we did not have enough past earthquake records of the lifelines in Algeria. Hence, we decided that the method of damage estimation would basically be selected from the Japanese method because recent damage experience due to earthquakes has already been included.

9) Damage estimation for the water supply and sewerage pipelines

The expert explained the fragility curve for the water supply and sewerage pipelines to the counterpart.

We decided on applying the coefficient for ground type, pipe diameter and pipe material.

10) Damage estimation for the medium voltage aerial cables

The expert explained the fragility curve for the aerial cables to the counterpart. We decided on applying the standard damage ratio.

11) Damage estimation for the medium voltage underground cables

The expert explained the fragility curve for the underground cables to the counterpart. We decided on applying the standard damage ratio.

12) Damage estimation for the medium pressure gas pipelines

The expert explained the fragility curve for the gas pipelines to the counterpart. We decided on applying the coefficients for pipe material - diameter.

13) Calculation of damage estimation

The expert calculated the damage on a 250 m grid system using the method that was decided on by the counterpart and the expert. The expert explained the result of the calculation and its interpretations.

14) Review of the entire method and result of the damage estimation

The counterpart and the expert conducted the review of the entire method and the result of the damage estimation. The counterpart was able to comprehensively understand the damage estimation for the infrastructure / lifelines.

(3) Recommendations and Conclusions

The counterpart and the expert worked together comprehensively on the damage estimation for the infrastructure / lifelines through this study, which began at the data collection stage, its compilation, preparation of the damage estimation to getting the result.

Unfortunately, some required data was not obtainable in this study; hence, some portions were based on assumptions (of course, both sides agreed about this matter). It is recommended that CGS starts to accumulate / collect / compile the damage data due to the earthquakes on infrastructure and lifeline engineering immediately, and will modify the damage estimation method utilized on this study in order to get more suitable results for Algeria.

12-4 Seismic Evaluation and Retrofitting of Buildings

12-4-1 Masonry Buildings

(1) Contents and Schedule

Items on which the technology transfer was conducted are the following:

1) Static seismic evaluation method for masonry buildings
2) Seismic retrofit methods for two strategic masonry buildings
3) Seismic retrofit methods for normal masonry buildings

Technology transfer for items 1 to 3 was conducted in the periods of October 2005 to July 2006, from October 2005 to April 2006 attended Mr. REMAS, and from May 2006 to July 2006 attended Mr. MEHANI and Mr. REMAS.

The overall schedule, counterpart personnel and transfer items are summarized in Table 12-5.

Table 12-5 Schedule and Contents of Technology Transfer for Seismic Evaluation and Retrofitting of Masonry Buildings

Contents	Counterpart	Study Team	Date
Site and building inspection of the Palace, obtained design drawing on 19 Oct.	A. Remas	Kagawa	11/10/05
Site and building inspection of the SENATE, obtained design drawings on 10 Nov.	A. Remas	Kagawa	22/10/05
Discussion of evaluation method and policy for the Palace	A. Remas	Kagawa	23/10/05
Discussion of evaluation method and policy for the SENATE	A. Remas	Kagawa	24/10/05
Discussion of construction method of old masonry	A. Remas	Kagawa	25/10/05
Discussion of bearing shear strength of old masonry	A. Remas	Kagawa	26/10/05
2nd building inspection of the Palace	A. Remas	Kagawa	30/10/05
Seismic evaluation work for the Palace parallel work with A. Remas and Kagawa	A. Remas	Kagawa	31/10 – 09/11/05
2nd building inspection of the SENATE	A. Remas	Kagawa	07/11/06
Seismic evaluation work for the SENATE parallel work with A. Remas and Kagawa (by e-mail)	A. Remas	Kagawa	12/04 – 26/04/06
Evaluation method and judging criteria for Masonry	Y. Mehani, A. Remas	Kagawa	16/05/06
Outline of 1st to 3rd level seismic evaluation for RC buildings	Y. Mehani, A. Remas	Kagawa	20/05/06
Discussion of static evaluation method for Masonry buildings	Y. Mehani, A. Remas	Kagawa	21/05/06
Discussion of dynamic evaluation method for Masonry building	Y. Mehani, A. Remas	Kagawa	22/05/06
Evaluation method for the Palace	Y. Mehani, A. Remas	Kagawa	23/05/06
Evaluation method for the SENATE	Y. Mehani, A. Remas	Kagawa	24/05/06
Retrofit method with seismic isolation system for the Palace and the SENATE	Y. Mehani, A. Remas	Kagawa	27/05/06
Retrofit method using RC shear walls for the SENATE	Y. Mehani, A. Remas	Kagawa	29/05/06
Retrofit method using mortar grouting for the Palace	Y. Mehani, A. Remas	Kagawa	03/06/06
Retrofit method using mortar grouting for the SENATE	Y. Mehani, A. Remas	Kagawa	05/06/06
Retrofit method using mortar grouting for the SENATE	Y. Mehani, A. Remas	Kagawa	06/06/06
Retrofit methods for normal Masonry buildings	Y. Mehani, A. Remas	Kagawa	04/06/06
presentation to CGS “Seismic Evaluation and Retrofit for Masonry Buildings”	Y. Mehani, A. Remas	Kagawa	08/06/06

(2) Results

1) The seismic evaluation method of masonry buildings was selected the static method with average shear stresses of bearing wall unit. The dynamic analysis method for existing masonry was not adopted because the characteristic of restoring force in the modeling can not be employed where there is no or very little tensile strength in the wall joint material. Both strategic buildings were judged as “unsafe buildings” by our seismic evaluation based on the wall shear strength of 0.056 N/mm^2. However, it would be better to confirm the actual shear strength of the walls by core sampling tests or other methods.

2) Many types of seismic retrofit methods for masonry structures were discussed and studied, including the base isolation system for the Palace and the SENATE buildings.

3) Some common seismic retrofit methods were also discussed and confirmed based on ordinarily methods with load transfer.

(3) Recommendations and Conclusions

1) There are many stone and brick masonry buildings in Algiers. However, the seismic capacity of the old masonry buildings is still unknown, because of the strength of the joint materials is still unknown. It is recommended to determine the strength of the joint materials with core sampling tests or other methods. Then, an engineer can determine the seismic safety of the various types of masonry buildings.

2) For the two strategic buildings, the base isolation system is recommended for the main and sub plans. This system is not popular in Algeria, but CTC Chlef is constructing its on own office building in Ain Defla city. We believe that Mr. Mehani and Mr. Remas understood the base isolation system’s effectiveness, and positively introduced this new technology for seismic upgrading of any type of buildings.

12-4-2 RC Buildings

(1) Contents and Schedule

Items on which the technology transfer was conducted are the following:

a) 2nd and 3rd level seismic evaluation of reinforced concrete buildings
b) Seismic retrofit for reinforced concrete buildings

Technology transfer for items 1 and 2 were conducted in the period of May 2006 to July 2006. The overall schedule, counterpart personnel and transfer items are summarized in Table 12-6.

Table 12-6 Schedule and Contents of Technology Transfer for Seismic Evaluation and Retrofitting of RC Buildings

Contents	Counterpart	Study Team	Date
Outline of seismic evaluation for RC buildings	Y. Mehani, A. Remas	Kagawa	16/05/06
Outline of 1st to 3rd level seismic evaluation for RC buildings	Y. Mehani, A. Remas	Kagawa	20/05/06
Outline of 2nd level seismic screening for RC structures	Y. Mehani, A. Remas	Inoue	07/06/06
Concept and estimation of ductility index, F	Y. Mehani, A. Remas	Inoue	10/06/06
Concept and estimation of effective strength factor α, and Index, Is	Y. Mehani, A. Remas	Inoue	11/06/06
Concept of ductility index and axial force, Index, Is, and earthquake damage	Y. Mehani, A. Remas	Inoue	12/06/06
Study of Seismic evaluation using a sample 'Standard' school building	Y. Mehani, A. Remas	Inoue	14/06/06
Seismic evaluation of a school building (by 'EXCEL' form) (1)	Y. Mehani, A. Remas	Inoue	17/06/06
Seismic evaluation of a school building (by 'EXCEL' form) (2)	Y. Mehani, A. Remas	Inoue	18/06/06
Study of seismic damage index, Iso, and earthquake damage	Y. Mehani, A. Remas	Inoue	19/06/06
Seismic evaluation of an apartment house and a hospital, Iso and RPA99 Ver. 2003	Y. Mehani, A. Remas	Inoue	20/06/06
Concept of seismic retrofit, and methodology	Y. Mehani, A. Remas	Inoue	21/06/06
Standard detail of seismic retrofit of RC structures	Y. Mehani, A. Remas	Inoue	25/06/06
Estimation of seismic retrofit of a school	Y. Mehani, A. Remas	Inoue	28/06/06
Outline of 3rd level seismic screening, Retrofit of an apartment house and a hospital	Y. Mehani, A. Remas	Inoue	01/07/06
Concept and estimation of ductility Index, F	Y. Mehani, A. Remas	Inoue	02/07/06
Revised Is of a school, explanation of anchor strength	Y. Mehani, A. Remas	Inoue	03/07/06
Estimation of 3rd level for walls, summary	Y. Mehani, A. Remas	Inoue	04/07/06
Presentation of 'seismic evaluation, retrofit and seismic demand index'	Y. Mehani, A. Remas	Inoue	08/07/06

(2) Results

Comments addressed in the CGS review report on the JICA interim report were thoroughly discussed. These comments concerned mostly two points;

a) Methodology of 2nd and 3rd level seismic evaluation for reinforced concrete structures. Only an explanation of 3rd level methodology was presented. No building example was offered because it would not be easy to conduct by hand only.

b) Details of seismic retrofit for reinforced concrete structures.

(3) Recommendations and Conclusions

The results of this third work period in Algiers concern the following two points:

a) We believe that Mr. Mehani and Mr. Remas understood our answers to the comments made by CGS to the JICA interim report (Methodology of 2nd and 3rd level seismic evaluation, and retrofitting) and agreed with them; they made no further comments after we presented our answers and explanations to their initial comments.

b) Mr. Mehani and Mr. Remas were given all necessary explanations to independently conduct 2nd level seismic evaluations and retrofit designs for reinforced concrete structures.

Table 12-7 List of Technical Documents Provided to the Algerian Side

Name of Document	Published	Language
- Standard for Seismic Evaluation of Existing Reinforced Concrete Buildings, 2001 - Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001 - Technical Manual for Seismic Evaluation and Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001 in Japan	2001	English
- Standard for Seismic Evaluation of Existing Reinforced Concrete Buildings, 2001 - Guidelines for Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001 - Technical Manual for Seismic Evaluation and Seismic Retrofit of Existing Reinforced Concrete Buildings, 2001 in Japan	2001	Japanese
Guideline for Seismic evaluation and Seismic Retrofit of Existing Steel Structure buildings for Enforcement order Law of seismic retrofit, 1996 in Japan	1996	Japanese
Construction Manual for Seismic Retrofit of Existing Steel Structure buildings, Revised Version, in Japan	1996	Japanese
Recommendation for the Design of Base Isolated Buildings, 2001 in Japan	2001	English
Structural Retrofit: Sample of Special Retrofit, Base Isolated Retrofit and Seismic Control Retrofit, in Japan		Japanese
Commentary on Technical Standard and Case Example of Base Isolated Buildings, in Japan		Japanese
Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation, FEMA 155/September 1988	1988	English
NEHRP Handbook for the Seismic Evaluation of Existing Buildings, FEMA -178/June 1992	1992	English
Seismic Rehabilitation of Buildings-Phase 1: Issues Identification and Resolution, FEMA - 237/November 1992	1992	English
Seismic Evaluation Handbook, FEMA -310	1999	English
Earthquake Damage Evaluation Data for CALIFORNIA, ATC-13 1985	1985	English
Evaluating the Seismic Resistance of Existing Buildings, ATC-14	1987	English
How to Protect Existing Buildings from Earthquake Attacks, Samples of Seismic Base Isolation and Seismic Control Retrofit		Japanese

Table 12-8 List of Technical Documents Provided from the Algerian Side

Name of Document	Published	Language
Algerian Rules for Seismic-resistance RPA 1981, Version 1983	1983	French
Algerian Rules for Seismic-resistance RPA 88	1988	French
Conception Rules and Calculations for Reinforced Concrete structures C.B.A.93	1993	French
Algerian Rules for Seismic-resistance RPA 99	1999	French
Algerian Rules for Seismic-resistance RPA 99/ Version 2003	2003	French
Seismic Strengthening and Repair of BYZANTINE Churches – Summary –		English
Basic and Applied Research Study for Seismic Modeling of Mixed Reinforced Concrete-Masonry Buildings Shaking Table Test of Reduced Scale Repaired Model – Preliminary Report –		English
Design and Construction of Stone and Brick-Masonry Buildings		English
Catalogue of Repair Works		French
Study of Seismic Vulnerability of building, Central Hospital 'Mustapha University'		English

12-5 GIS Data Development

(1) Contents and Schedule

The overall schedule and transfer items are summarized in Table 12-9. The counterpart personnel are listed in Table 12-10.

Table 12-9 Schedule and Contents of Technology Transfer for GIS Data Development

Contents	Study Team	Date
Difference between ArcCatalog & ArcMap	Kiyota	05/06/06
Displaying shape files (GIS data for ArcGIS)	Kiyota	05/06/06
Creating GIS data as shape files	Kiyota	05/06/06
Basic querying	Kiyota	06/06/06
Concept of projection cylinder - Description of projection; cylindrical or conical projection, spheroid, UTM and zone - Setting projection parameters on ArcCatalog - Re-project from GCS; geographic coordinate system (latitude & longitude) to UTM	Kiyota	06/06/06
Digitizing paper map (1) - Rectification - Creating polygons	Kiyota	06/06/06
Digitizing paper map (2); practical data resources - Creating polygons - Tables as Excel - Tables as Access - Linking shapes and tables	Kiyota	07/06/06
Creating microzoning cells (1) - Creating cells by editing - Concept - Creating raster from ASCII data - Raster to polygon	Kiyota	10/06/06

Contents	Study Team	Date
Creating microzoning cells (2) practical training - Creating raster from ASCII data according to given parameters - Raster to polygon - Link with the result of analysis	Kiyota	11/06/06
Table creation - Create table - Create table from ASCII file	Kiyota	13/06/06
Importing CAD data (1) - Importing tools ; basic - Creating building polygons - Select components of buildings and export them - Editing and correcting building polygons - Create topology and check the topology	Kiyota	13/06/06
Customizing tool menus	Kiyota	14/06/06
Importing CAD data (2) - Introducing ArcInfo WorkStation - Creating road center lines - Select the components of roads and export - Edit - Create center lines with ArcInfo tool - Intersect road polygons & road center lines and calculate width of road	Kiyota	14/06/06
Analyzing urban vulnerability (1); basic - Definition of urban vulnerability - Vulnerability elements - Finding urbanized areas	Tanaka, Kiyota	17/06/06
Analyzing urban vulnerability (2); advanced - Review of urban vulnerability - Finding urbanized areas (road connectivity and etc.,) - Road connection & isolation areas - Calculate vulnerability	Tanaka, Kiyota	18/06/06

Table 12-10 List of Attending Counterpart Personnel

Name	Organization
SAMIRA SAADI	CGS
MEHDI BOUKRI	CGS
RACHIDA DOUAR	URBANIS
AMEL GHARBI	URBANIS
ANISSA ALLOUANE	URBANIS
HANA METREF	URBANIS
FAOUZI SAHRAOUI	DGPC
RIADH ALIOUAT	DGPC
TAREK BENATTOU	INCT

The Objective of the GIS engineer in this study was to create a GIS database upon the request of related specialists, the geologist, seismologist, and other engineers, which is based on the availability or existence of related information. Under any circumstance, sources are digitally created material data (CAD) or paper maps. Hence, the scope of this technical transfer is to help understand how to create proper GIS data from paper material, how to convert the digitally created information and how to use the analytical results from other engineers.

Besides the scope, at the request of C.G.S. we have conducted special technical transfer lectures for understanding how to analyze the Urban Vulnerabilities.

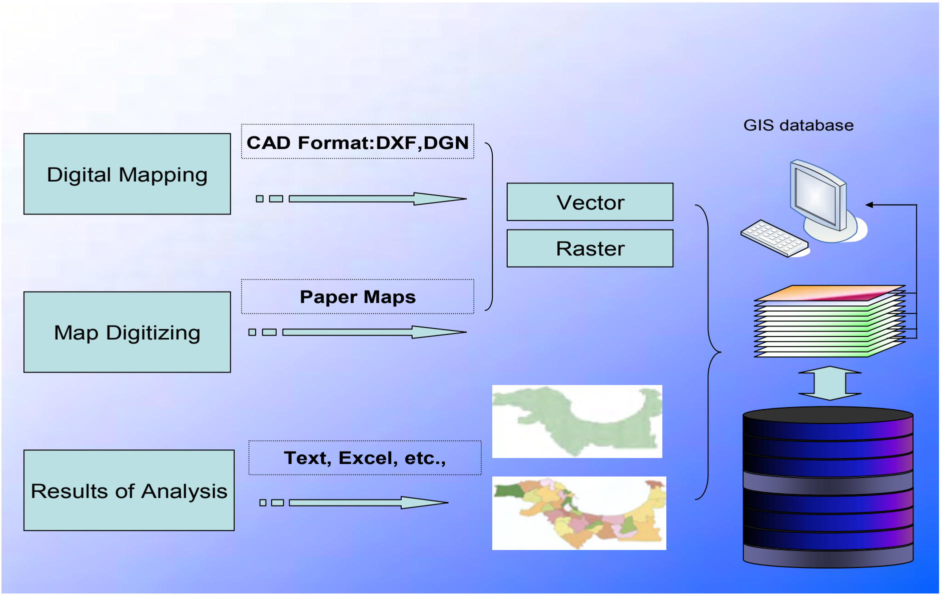


Figure 12-3 Flow of Information for Creating a GIS Database

(2) Results

Comments addressed in the CGS review report on the JICA interim report were thoroughly discussed. As regarding GIS, the comments addressed the idea that the planed interface of GIS should cover extra areas that were not covered by this project. In addition to this, inclusion of the topic of customizing the interface of the ArcMap into the technical transfer lecture was requested by DGPC as their special interest.

We have decided not to include this topic for the following reasons.

1) Customizing will be conducted to help create better functionality of particular software by reducing the steps in particular circumstances. Hence the creation can not cover the things that go beyond the precondition. In fact, all the steps can be carried out with given GIS software without customizing.

2) The objective of the technical transfer lecture regarding GIS for this project was to help understand how to construct the GIS database for Microzoning. Although introduction of this topic was covered in the workshop on June 14th, 2006, customizing the interface is out of the scope of this project.

3) More than one year of programming experience is needed to understand this topic and especially, knowledge of object oriented programming.

The following topics have been covered in the technical transfer workshop as planned.

1. Learning basic skills of handling ArcGIS 9.x and becoming accustomed to it.
2. Digitizing information from paper maps to a GIS database as points, lines, and polygons.
3. Importing CAD data and process it for a proper GIS.
4. Creating Microzoning Cells to express the results of Analysis.

(This technique can be applied to Commune polygons too)

The following two important topics have also been addressed in the workshop

1. Necessity of the counterpart personnel exercising their own efforts to develop skills related to GIS in addition to the workshop that were presented.
2. No simple automatic solution can be applied for construction of a GIS database; it is a time and work consuming operation.

(3) Recommendations and Conclusions

The results of this technical transfer concern 1) how to manipulate the ArcGIS and 2) acquire the knowledge and skills of construction of a GIS database.

Basically no single GIS software can perform and fulfill the needs of the various users, thus, the skills and knowledge of utilization of other commercial software for help filling out the weak points of ArcGIS have been transferred in the workshop while learning the limitations and advantages of ArcGIS (ArcView).

As a recommendation, the following items should be remembered as the counterparts undertake their own projects.

1) The practice and application of the skills and knowledge is the next step and this requires the cooperation of other related specialists like seismic hazard analysts, sharing the knowledge among the specialists and refining the methods.

No single method can be performed. The method chosen depends on the availability and compatibility of the existing information and resources, like budget, software and etc.

2) The most basic conception that a GIS engineer must understand is that the relationship between the productivity and the accuracy of a GIS database is a trade off. Also, most of the time, there are very few automated steps that can be adopted for the construction of the GIS database, because of the complexity of the topology.